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h a freely secreting wound-surface it
mposed and became powerfully anti-
ococcus pyogenes and the staphylococ-
ng to be the cause of the chemical de-

litions and indications already specified
t curettement of the puerperal uterus is
. In the very large majority of cases of
emia, the local lesion to which septic
cess is situated somewhere between the
vulvar orifice, and, as remarked by
ell-contracted uterus is almost proof
." The mere presence of an offensive
per se, an indication for excochleation.
ase clearly and forcibly when he says:
g[28] the people say: 'A woman in child-
erself out.' Let him who prefers a more
n say: 'Nature must cleanse and evacu-
t passages of the puerperal woman, and
ess the odor of the puerperal woman is
This is an extremely simple process, sim-
asier and simpler than, the evacuation of
ng which process the human being does
itly, but yet is thoroughly healthy. The
ges have a more powerful musculature
, and wide-open excretory ducts, while
conquer and open the sphincter muscle
ven very foully smelling secretions do
ong as their normal dejection is not dis-

dication is fulfilled by the institution of
al antiphlogosis. Absolute rest in bed
ubitus, the legs flexed upon the thighs
y pillows, until all acute symptoms have
he first and most important regulation.
olication of cold is an efficient remedy,
acute stages of pelvi-peritonitis. Dry
ployed in the form of india-rubber bags
boxes (Esmarch) containing ice. A more
f applying dry cold is that described by
the name of mediate irrigation. A vul-
ubber tube, sixteen or twenty feet long,
an inch thick, is coiled to fit the part,
ition by a roller. Water, of any desired
caused to pass through this tube from a
the patient's level. Leiter, of Vienna,
an ingenious modification of this appa-
bstitution of very flexible metallic tubing
zed india-rubber. The intensity of the
by the insertion of a towel or compress
n and the "heat-regulator."
be applied per vaginam, in accordance
r's[29] suggestion. Thin metallic capsules,
and shape, similar to Bozeman's hard
for vaginal dilatation, are fitted with af-
ent tubes, and connected with suitable

nction with moisture, in the form of the
e, flaxseed meal, and hop poultices, is less
ld in the limitation of the local inflamma-
nitial stages, but is probably more exten-
in America. Thus Emmet[30] advises the
al injections immediately after reaction,
it is the only means we possess for abort-
cellulitis—which *it will do*, if *thoroughly beginning*"—an opinion consistent with
ews on the pathology of the condition,
our recent knowledge of causation and
ce of other clinicians. We are informed
hority, moreover, that Leiter's coils and
almost exclusively employed, during the
f pelvi-peritonitis and pelvic cellulitis, in
ospital of New York.
of local blood-letting has passed through
ses of professional opinion, even in our
anzoni, Spiegelberg, and Schroeder rec-
pplication of leeches—ten to twelve—as
to the focus of inflammation—inguinal
m, or inner surface of the thigh. Ols-

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A

REFERENCE HANDBOOK

OF THE

MEDICAL SCIENCES

EMBRACING THE ENTIRE RANGE OF

SCIENTIFIC AND PRACTICAL MEDICINE

AND

ALLIED SCIENCE

BY VARIOUS WRITERS

ILLUSTRATED BY CHROMOLITHOGRAPHS AND FINE WOOD ENGRAVINGS

EDITED BY ALBERT H. BUCK, M.D.
NEW YORK CITY

VOLUME V.

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LIST OF CONTRIBUTORS TO VOLUME V.

BENJAMIN VAUGHAN ABBOTT.....New York, N. Y.
Author of "Abbott's Law Dictionary," and various digests.

T. JOHNSON ALLOWAY, M.D..Montreal, Canada.
Gynæcologist to the Montreal Dispensary; Assistant Surgeon, Montreal General Hospital.

ADOLF ALT, M.D.....St. Louis, Mo.

DALLAS BACHE, M.D. Fort Adams, Newport, R. I.
Surgeon, United States Army.

FRANK BAKER, M.D.....Washington, D. C.
Professor of Anatomy, Medical Department of Georgetown University.

J. F. BALDWIN, M.D..... Columbus, O.

CHARLES P. BANCROFT, M.D....Concord, N. H.
Superintendent of the New Hampshire Asylum for the Insane.

WILLIAM MORROW BEACH, M.D.....London, O.

HENRY W. BERG, M.D.....New York, N. Y.
Assistant Surgeon, New York Orthopædic Dispensary and Hospital.

W. R. BIRDSALL, M.D.....New York, N. Y.
Physician to the Department for Nervous Diseases, Manhattan Eye and Ear Hospital.

W. P. BOLLES, M.D.....Boston, Mass.
Professor of Materia Medica and Botany, Emeritus, at the Massachusetts College of Pharmacy; Visiting Surgeon to the Boston City Hospital.

EDWARD H. BRADFORD, M.D .....Boston, Mass.
Assistant in Clinical Surgery, Harvard Medical College; Surgeon to the Children's Hospital of Boston.

L. BREMER, M.D.....St. Louis, Mo.

EDWARD TUNIS BRUEN, M.D..Philadelphia, Pa.
Assistant Professor of Physical Diagnosis, University of Pennsylvania; Physician to Philadelphia (Blockley) Hospital; Lecturer on Pathology, Women's Medical College, Philadelphia.

ALBERT H. BUCK, M.D.....New York, N. Y.
Clinical Lecturer upon Diseases of the Ear, College of Physicians and Surgeons, New York; Consulting Aural Surgeon, New York Eye and Ear Infirmary.

WILLIAM H. CARMALT, M.D..New Haven, Conn.
Professor of Surgery, Yale University; Surgeon to New Haven Hospital.

RUSSELL H. CHITTENDEN, Ph.D...New Haven, Conn.
Professor of Physiological Chemistry, Yale University.

HENRY C. COE, M.D.....New York, N. Y.
Instructor in Gynæcology, New York Polyclinic; Pathologist to the Woman's Hospital in the State of New York; Visiting Obstetrician, New York Infant Asylum.

W. J. CONKLIN, M.D.....Dayton, O.
Professor of Diseases of Children, Starling Medical College.

W. T. COUNCILMAN, M.D.....Baltimore, Md.
Associate Professor of Pathological Anatomy, Johns Hopkins University,

EDWARD CURTIS, M.D..... ...New York, N. Y.
Professor Emeritus of Materia Medica and Therapeutics, College of Physicians and Surgeons, New York.

N. S. DAVIS, M.D.....Chicago, Ill.
Professor of the Principles and Practice of Medicine and of Clinical Medicine, Chicago Medical College; Physician to the Mercy Hospital.

ROBERT H. M. DAWBARN, M.D..New York, N. Y.
Examiner in Surgery, and Instructor in Minor Surgery, College of Physicians and Surgeons; Visiting Physician to the Northwestern Dispensary, Department of Diseases of Children.

D. BRYSON DELAVAN, M.D.....New York, N. Y.
Professor of Laryngology and Rhinology, New York Polyclinic; Chief of Clinic, Department of Diseases of the Throat, College of Physicians and Surgeons in the City of New York.

WILLIAM S. DENNETT, M.D.....New York, N. Y.
Assistant Surgeon, Ophthalmic Department, New York Eye and Ear Infirmary.

WILLIAM H. FLINT, M.D.....New York, N. Y.
Physician to the Roosevelt Hospital, Out-Patient Department.

GEORGE B. FOWLER, M.D.....New York, N. Y.
Professor of Physiological Chemistry, New York Polyclinic; Physician to the New York Infant Asylum.

GEORGE R. FOWLER, M.D.....Brooklyn, N. Y.
Surgeon, St. Mary's Hospital.

JAMES M. FRENCH, M.D.....Cincinnati, O.
Lecturer on Morbid Anatomy and Demonstrator of Pathology, Medical College of Ohio; Microscopist and Pathologist to St. Mary's Hospital.

SIMON H. GAGE, B.S. .....Ithaca, N. Y.
Assistant Professor of Physiology, and Lecturer on Microscopical Technology, Cornell University.

WILLIAM W. GANNETT, M.D.....Boston, Mass.
Assistant in Pathological Anatomy, Harvard University.

V. P. GIBNEY, M.D..... ....New York, N. Y.
Professor of Orthopædic Surgery, New York Polyclinic; Orthopædic Surgeon to the Nursery and Child's Hospital.

ALBERT L. GIHON, M.D. .....Mare Island, Cal.
Medical Director, United States Navy.

H. GRADLE, M.D.....Chicago, Ill.
Professor of Physiology, Chicago Medical College.

JAMES E. GRAHAM, M.D.....Toronto, Canada.
Lecturer on Diseases of the Integumentary System, Toronto School of Medicine.

JOHN GREEN, M.D.....St. Louis, Mo.
Professor of Ophthalmology, St. Louis Medical College.

CHARLES E. HACKLEY, M.D. ..New York, N. Y.
Attending Physician, New York Hospital.

ALLAN McLANE HAMILTON, M.D....New York, N. Y.
Professor of Diseases of the Mind and Nervous System, New York Polyclinic.

HORACE T. HANKS, M.D..... New York, N.Y.
Professor of the Diseases of Women, New York Post Graduate Medical School; Assistant Surgeon, Woman's Hospital in the State of New York.

CHARLES HARRINGTON, M.D..... Boston, Mass.
Instructor in Chemistry, Harvard Medical College.

FREDERICK P. HENRY, M.D..Philadelphia, Pa.
Professor of Pathology and Microscopy, Philadelphia Polyclinic and College for Graduates in Medicine; Physician to the Hospital of the Protestant Episcopal Church.

S. S. HERRICK, M.D.....San Francisco, Cal.

WILLIAM B. HILLS, M.D.....Boston, Mass.
Assistant Professor of Chemistry, Harvard University.

JAMES B. HUNTER, M.D..... New York, N. Y.
Professor of Gynæcology, New York Polyclinic; Surgeon to the Woman's Hospital; Surgeon to the New York Cancer Hospital.

OSCAR B. IRELAND.....Springfield, Mass.
Actuary of the Massachusetts Mutual Life Ins. Co.

W. W. JAGGARD, M.D.....Chicago, Ill.
Professor of Obstetrics, Chicago Medical College, Medical Department of Northwestern University; Obstetrician to Mercy Hospital.

SAMUEL KETCH, M.D.....New York, N. Y.
Senior Assistant Surgeon, New York Orthopædic Dispensary and Hospital.

HENRY KOPLIK, M.D..... .....New York, N. Y.
Late Assistant in the Pathological Laboratory of the Alumni of the College of Physicians and Surgeons, in the City of New York.

HENRY LEFFMANN, M.D.....Philadelphia, Pa.
Professor of Clinical Chemistry and Hygiene in the Philadelphia Polyclinic; Assistant to the Chair of Chemistry, Jefferson Medical College.

R. L. MacDONNELL, M.D.....Montreal, Canada.
Demonstrator of Anatomy and Lecturer on Hygiene, McGill University.

JOHN NOLAN MACKENZIE, M.D. Baltimore, Md.
Surgeon to the Baltimore Eye, Ear, and Throat Charity Hospital.

F. A. MANNING, M.D.....New York, N. Y.
Late House Surgeon, New York Hospital; Instructor in Surgery, Corps of Examiners, College of Physicians and Surgeons.

RUDOLPH MATAS, M.D.....New Orleans, La.
Demonstrator of Anatomy, Medical Department of Tulane University of Louisiana; Visiting Surgeon to the Charity Hospital.

T. WESLEY MILLS, M.D.....Montreal, Canada.
Professor of Physiology, McGill University.

CHARLES SEDGWICK MINOT, M.D.....Boston, Mass.
Instructor in Histology and Lecturer on Embryology, Harvard University.

WILLIAM OLIVER MOORE, M.D.....New York, N. Y.
Professor of Diseases of the Eye and Ear, New York Post-Graduate Medical School; Assistant Surgeon, Ophthalmic Department, New York Eye and Ear Infirmary.

ETHELBERT CARROLL MORGAN, M.D....Washington, D. C.
Professor of Laryngology, Medical Department, University of Georgetown, D. C.; Surgeon-in-Charge of Diseases of the Throat and Ear in the Providence Hospital, and of the Throat and Lungs in the Central Dispensary.

ROBERT B. MORISON, M.D.....Baltimore, Md.
Professor of Dermatology and Syphilis, Baltimore Polyclinic and Post-Graduate Medical School.

WILLIAM H. MURRAY, M.D....Plainfield, N. J.
Late House Surgeon, New York Hospital House of Relief.

WILLIAM P. NORTHRUP, M.D..New York, N. Y.
Pathologist to the New York Foundling Asylum.

CHARLES TALBOT POORE, M.D.....New York, N. Y.
Visiting Surgeon, St. Mary's Hospital.

F. PEYRE PORCHER, M.D.....Charleston, S. C.
Professor of Materia Medica and Therapeutics, Medical College of the State of South Carolina; Attending Physician, City Hospital of Charleston.

ABNER POST, M.D..... Boston, Mass.
Visiting Surgeon to the Boston City Hospital; Clinical Instructor in Syphilis, Harvard University.

JAMES J. PUTNAM, M.D.....Boston, Mass.
Physician to Out-Patients with Diseases of the Nervous System, Massachusetts General Hospital; Instructor in Diseases of the Nervous System, Harvard Medical College.

LEOPOLD PUTZEL, M.D.....New York, N. Y.
Visiting Physician to Randall's Island Hospital.

JOSEPH RANSOHOFF, M.D..... Cincinnati, O.
Professor of Descriptive Anatomy and Clinical Surgery, Medical College of Ohio; Surgeon to the Good Samaritan Hospital.

EDWARD T. REICHERT, M.D..Philadelphia, Pa.
Professor of Physiology, University of Pennsylvania.

CHARLES RICE, Ph.D..... New York, N. Y.
Chairman of the Committee of Revision and Publication of the Pharmacopœia of the United States of America (1880–90).

HUNTINGTON RICHARDS, M.D.....New York, N. Y.
Aural Surgeon, New York Eye and Ear Infirmary; Chief of Clinic, Department of the Ear, College of Physicians and Surgeons in the City of New York.

CHARLES VALENTINE RILEY, Ph.D....Washington, D. C.
United States Entomologist; Honorary Curator of Insects, National Museum.

HENRY A. RILEY..... New York, N. Y.
Attorney and Counsellor-at-Law.

GEORGE ROSS, M.D..... Montreal, Canada.
Professor of Clinical Medicine, McGill University; Physician to the Montreal General Hospital.

EDWARD W. SCHAUFFLER, M.D.. Kansas City, Mo.
Professor of the Principles and Practice of Medicine, Kansas City Medical College.

N. SENN, M.D.....Milwaukee, Wis.
Attending Surgeon to the Milwaukee Hospital; Professor of the Principles and Practice of Surgery and of Clinical Surgery in the College of Physicians and Surgeons, Chicago.

FREDERICK C. SHATTUCK, M.D..Boston, Mass.
Instructor in the Theory and Practice of Medicine, Harvard Medical College; Visiting Physician to the Massachusetts General Hospital.

FRANCIS J. SHEPHERD, M.D....Montreal, Can.
Professor of Anatomy, McGill University; Surgeon to the Montreal General Hospital.

M. ALLEN STARR, M.D.....New York, N. Y.
Attending Physician, Department of Diseases of the Nervous System, Demilt Dispensary.

THOMAS L. STEDMAN, M.D...New York, N. Y.
Late Attending Surgeon, New York Orthopædic Dispensary.

GEORGE M. STERNBERG, M.D..Baltimore, Md.
Surgeon, United States Army.

JAMES STEWART, M.D.....Montreal, Canada.
Professor of Materia Medica and Therapeutics, McGill University.

JAMES K. THACHER, M.D....New Haven, Conn.
Prof. of Physiology and Clinical Medicine, Yale University; Attending Physician, New Haven Hospital.

WILLIAM GILMAN THOMPSON, M.D..... New York, N. Y.
Lecturer on Physiology, Medical Department, University of New York; Visiting Physician to the Presbyterian Hospital; Physician to Roosevelt Hospital, Out-Patient Department.

ARTHUR VAN HARLINGEN, M.D..Philadelphia, Pa.
Professor of Diseases of the Skin in the Philadelphia Polyclinic and College for Graduates in Medicine; Consulting Physician to the Dispensary for Skin Diseases.

CHARLES WARE, M.D.....New York, N. Y.
Assistant Gynæcologist, Out-Door Department of Roosevelt Hospital.

BENJAMIN F. WESTBROOK, M.D.....Brooklyn, N. Y.
Physician-in-Chief to the Department for Diseases of the Chest, St. Mary's Hospital.

RUDOLPH A. WITTHAUS, M.D.....New York, N. Y.
Professor of Chemistry, Medical Department of the University of New York.

SAMUEL B. WOODWARD, M.D.....Worcester, Mass.

A REFERENCE HANDBOOK

OF THE

MEDICAL SCIENCES.

MILIARIA is an acute inflammatory disease of the sweat-glands, accompanied by the formation of papules or vesicles from the size of a pin-point to that of a millet-seed, and giving rise to pricking, burning, or itching sensations.

The eruption breaks out suddenly, over irregular areas of various size, in the form of numerous minute, pointed, bright-red papules, which, although often crowded very closely together, rarely tend to coalesce. The appearance of the eruption is apt to be preceded and accompanied by more or less profuse sweating. Not infrequently the pointed papules are surmounted by small vesicles, or vesicles surrounded by a red areola may appear interspersed among the papular lesions.

The vesicular lesions, at first transparent, soon become opaque and yellowish-white, and give a peculiar yellowish cast to the skin. Both forms of lesions run an acute and rapid course, drying up usually in a few days, and being followed by slight desquamation. Fresh crops, however, may succeed one another as long as the cause producing the disease is active.

All parts of the body may be attacked, but certain regions, as the abdomen, chest, neck, forehead, and arms, are commonly invaded. The disorder, as has been said, makes its appearance suddenly, without premonitory symptoms, and quickly assumes its definite characters; a few hours may suffice for its development.

The affection varies greatly in intensity at different times and in different cases. It may appear and disappear without apparent cause. The taking of food and hot drinks is sufficient to aggravate it, or even to cause a fresh outbreak, when there is a disposition to the disease.

Miliaria is caused by too profuse sweating. This may be produced by excessive external heat, or by the use of unsuitable and too heavy clothing. The writer has observed one case of miliaria in cold weather, brought on by unilateral sweating of the face of nervous origin. It is very commonly met with in the summer months, and especially in hot climates, where it is at times a serious affection. This prevalence in hot climates caused the name of *lichen tropicus* to be formerly applied to this disease. Fleshy persons who perspire profusely and children are especially liable to it. The superfluous clothing with which infants are often over-burdened, is a cause of miliaria in winter as well as in summer. A weak and debilitated condition of the system seems to predispose to the disease in some cases.

Miliaria is an inflammatory disorder of the sweat-glands, congestion taking place with great rapidity about the mouths of the ducts, and being followed by exudation.

The diagnosis of miliaria is rarely difficult. The fact of its occurring in hot weather and in connection with profuse perspiration, the rapidity of its appearance, and its distribution in those localities where the secretion of sweat is most abundant, together with the uniform minute and discrete character of the lesions, will serve to distinguish it from eczema, the only affection with which it is likely to be mistaken.

The treatment of miliaria as it occurs in temperate climates is simple. Usually any mild astringent wash, as the lotio nigra, or an absorbent powder, as oxide of zinc or lycopodium, is sufficient. In more stubborn cases bathing with vinegar-and-water, or with a lotion of sulphate of copper, ten grains to the ounce, is useful. Cold-water baths or baths containing alkalies, and followed by dusting with an astringent powder, are beneficial. The well-known McCall Anderson's powder may be used with benefit when the skin has not become abraded by rubbing and scratching. It is composed as follows: ℞. Pulv. camphoræ, 6 Gm. (℥ jss.); pulv. amyli, pulv. zinci oxidi, āā 32 Gm. (℥ j.). M.

As regards general treatment, the use of refrigerant diuretics, such as the citrate, nitrate, or acetate of potassium, well diluted, will be found of decided value. Acidulated drinks, saline laxatives, plain food, the avoidance of hot fluids, light clothing, and a cool apartment and absolute rest are to be recommended. When repeated crops of the more vesicular lesions continue to appear, and especially when there is any debility, constitutional remedies of a tonic character, as iron and quinine, may be required.

In temperate climates miliaria is seldom obstinate. If allowed to run on eczema may be developed from irritation and scratching, which, of course, calls for special treatment.

NOTE.—The subject of miliaria has been much confused by the division into several distinct affections of what are merely stages and forms of the same eruption. *Miliaria alba*, *miliaria rubra*, *miliaria papulosa*, and *miliaria vesiculosa*, as also the old term *lichen tropicus*, all cover one and the same disease, that described above under the simple title of miliaria, of which the popular name is "prickly heat." The somewhat similar affection of the sweat-glands which occurs in the course of certain fevers, and of debilitated conditions, and not as the result of heat and excessive sweating, will be found described under Sudamen. *Arthur Van Harlingen.*

MILIUM is a disease of the sebaceous glands of the skin, characterized by the formation of small, roundish, whitish, non-inflammatory elevations situated beneath the epidermis.

The lesions are situated for the most part upon the face, especially about the eyelids, on the prominence of the cheeks, and on the forehead; they may, however, occur on other parts of the body. They may occur singly or in great numbers. Usually one or two may be seen on the inner side of the eyelids, or a half dozen or so over the prominence of the cheek. The lesions are whitish, smooth-rounded, and with a peculiar pearly look. Their ordinary size is that of a pin-head or smaller, but they may occur the size of a small split pea. The average size is that of a millet-seed, from which the name is derived. They may be felt as more or less firm, hard bodies, imbedded superficially in the skin. They sometimes form rapidly, but once formed, show no tendency to grow or change in appearance, remaining unaltered at times for years. No inconvenience beyond

disfigurement is caused by their presence. Milium is sometimes met with in connection with acne or comedo, but quite as often without the concurrence of these affections. Occasionally the contents of the lesions of milium undergo calcareous degeneration, and we then have cutaneous calculi (*q.v.*).

Milium has always been regarded as having its seat in the sebaceous glands, although some recent investigators have denied this. It is believed to consist in an accumulation of sebum within the gland, which, owing to obliteration of the duct from some cause or other, is unable to escape. The covering consists of epithelium and the contents tend to become inspissated, but, unlike the somewhat similar disease, comedo, there is no tendency to inflammation.

The treatment of milium, when the lesions are few in number, consists in opening the little tumors with a knife and evacuating their contents. Sometimes it is desirable to apply a small drop of tincture of iodine subsequently, with the view of exciting a substitutive inflammation to prevent recurrence of the lesion. Hardaway recommends electrolysis with the needle and battery, as in the operation for the permanent removal of hair. When the lesions are numerous, frictions with sapo viridis or sand-soap may be employed; care being taken not to inflame the skin. Some soothing ointment should, in fact, be employed subsequent to the frictions.

Closely allied, in some respects, to milium are sebaceous cysts, which will be treated of subsequently under that head. *Arthur Van Harlingen.*

MILK, DIETETIC AND THERAPEUTIC USES OF.

Milk, aside from its general and universal use as a food, has many special uses in the department of therapeutics. In the present article, unless otherwise stated, when the word milk is used, cow's milk is understood. Human milk will be found treated under the headings Infancy, Wet-nursing, Weaning. In addition to cow's milk, for various economic reasons, the milk of goats, asses, mares, camels, etc., is occasionally employed. These varieties of milk present slight differences in chemical composition, taste, and odor. (See next article, on Milk, Physiol. and Pathol. Chem. of.)

Cow's milk contains the necessary chemical elements for maintaining life—C,O,N, and H,—in fairly economical proportion, combined in the form chiefly of water, casein, albumen, fat, or butter, and lactose. In addition there are traces of numerous salts. It is therefore possible to support adult life for some time upon an exclusive milk diet. But this soon becomes excessively wearisome, and gastro-intestinal derangements are apt to ensue in a few days or weeks. Independent of nausea, there develops an excessive loathing of the taste of the milk. But other substances may be added in small amount, milk being retained as the main factor in the diet, for a much longer period. The cause of this disagreement is found in the fact that there is too much nitrogenous matter in proportion to the carbo-hydrates, and to get enough carbohydrates too much proteid is taken, which interferes with digestion. The human body requires for daily consumption 18.3 Gm. N and 328.9 Gm. C. To obtain the requisite N from milk 2,905 Gm. must be drunk, but to obtain the requisite C 4,652 Gm. must be taken. Although milk answers very well as an exclusive diet for the first year of life, it is not adapted as such for adults. It is usually omitted from the dietary of athletes in training, and with many persons it disagrees, producing "biliousness," constipation, and various dyspeptic symptoms. On the other hand, in many cases of weak stomach, in fevers (where the nitrogenous metabolism is great), etc., an exclusive, or almost exclusive, milk diet proves highly beneficial, and is excellently tolerated. The normal period for the complete digestion of milk is about three hours.

The *Causes of the Disagreement of Milk* may be several: 1. Contamination by disease-germs from the cow. 2. Poisonous foods eaten by the cow. 3. Extraneous disease-germs. 4. Pollution of the milk by the dealer. 5. Souring or decomposition. 6. The coagula formed in the stomach in the case of cow's milk are usually large and somewhat tough, and if the stomach be feeble they are difficult of digestion. The gastric juice fails to disintegrate the casein within a reasonable time, the casein irritates the gastric mucous membrane, and alters the character of the gastric juice. An excess of lactic acid is developed from the milk-sugar, and various complicated fermentative changes ensue, which are still imperfectly understood.

The important differences between human and cow's milk are, that woman's milk is sweeter, it contains less butter and casein, and the casein forms a much smaller clot and is more quickly dissolved. Human milk is normally alkaline. The reaction of cow's milk varies, and it may be acid.

Goat's milk disagrees with many because it is too rich in fat; moreover, the odor is strong and disagreeable. Infants do not thrive upon it, for it is apt to occasion vomiting and diarrhœa.

Mare's and *ass's milk* contains less nitrogenous matter and fat, and more sugar, than cow's milk. Ass's milk is very sweet and easy of digestion, although it may have a tendency to cause diarrhœa if taken alone. The casein of mare's milk is intermediate in digestibility between that of human and cow's milk. The differences in the milk of different animals are largely in the taste and odor, and the essential ingredients vary comparatively slightly in relative quantity.

Milk, Lac. is officinal in the British Pharmacopœia. It is used in the preparation of the mixture of scammony.

The *sugar of milk*, Saccharum Lactis, lactose (lactine), is officinal in the U. S. Pharmacopœia for use in preparation of abstracts, triturates, denarcotized opium, etc. It exists in milk in the proportion of 0.74 to 4.5 per cent. As compared with cane-sugar, it is harder, less sweet, and less soluble; hence it is better suited for trituration. It is sold in lumps at the apothecaries', to be added to milk for infants. It has the objection, when thus used, of being much more readily fermentable in the stomach than cane-sugar, and it may produce gastric irritation and colic from the evolution of gas (CO_2, etc.).

Milk-sugar is not directly susceptible of alcoholic fermentation. Alone it is stable, but in the presence of decomposing nitrogenous matter it is converted into lactic acid, which makes the milk sour. The relative and absolute quantity of lactose varies considerably. As a general rule, it diminishes as the fat and casein increase. It is said to be increased by anæmia, diminished by uterine and vaginal catarrhs, and by menstruation. (Comp. art. Weaning.) The sugar of milk probably never remains long unchanged in the stomach. In a dog's stomach it has not been found later than one hour after its ingestion (Frerichs). (For the use of milk-sugar in diabetes, see art. Diabetes, vol. ii., p. 416.)

The *casein* of milk, after entering the stomach, is coagulated and forms "curds" or lumps of varying size and toughness, which enclose the fat-globules. The curds are soon partially dissolved again by the gastric juice, and the proteid matter is converted into peptone or one of its intermediate forms—dyspeptone—(Maly). The liberated fat-globules then coalesce. Probably a certain proportion of the curds pass into the duodenum undissolved, where their digestion is completed by the pancreatic and biliary (?) ferments. In the frequent indigestion of young infants the curds may pass out by the rectum undissolved. This happens much more rarely in adults. The coagula are finer when a little cheese is eaten with the milk: hence milk and cheese are often well assimilated together.

Several of the digestive fluids in man possess the power of "curdling" milk, or of coagulating the casein. This process is artificially accomplished by adding a decoction in brine made from the mucous membrane of the middle stomach of the calf. This membrane secretes a ferment called "rennet," which may also be obtained in a dry and powdered form. The curdling of milk in the stomach does not depend upon the acidity of the gastric juice, for it occurs also in neutral or alkaline media. Moreover, pure pepsin hardly curdles milk at all. Hence it is sup-

posed (Kemmerich) that the gastric juice contains a special milk-curdling ferment. Such a ferment has been demonstrated in the pancreatic secretion, but its identity with the gastric ferment is not established. Rennet acts best in an acid medium, and it possesses very feeble proteolytic power.

The *salts* and water of the milk are absorbed to some extent in the stomach. In some persons the absorption is rapid, and the blood-pressure being increased by the volume of the fluid, milk has quite a marked diuretic action when drunk rapidly in large amount.

An *excess of acidity* in the stomach converts the milk-sugar rapidly into lactic acid, coagulates the proteid matter, and decomposes the alkaline salts of the milk, and liberates phosphoric acid. This results in gastro-enteric irritation, and diarrhœa ensues, during which undigested coagula are sometimes voided.

The *reaction* of cow's milk is variable. It is often acid, and hence the frequent necessity of giving antacids to infants with their milk. This variation depends upon the "amphoteric" reaction; that is, the relative amount of potassium biphosphate and of the two-thirds phosphate of potassium is disturbed. The biphosphate in excess hastens the coagulation of the proteids, and occasions the acid reaction. If warmed, the milk may again become alkaline (Sohxlet, Heintz).

The formation of large coagula in the stomach may be prevented in a great variety of ways, chiefly mechanical. The addition of plain water, soda-water, or lime-water in equal parts will often prevent it. Starchy foods in a fine state of division, like arrowroot, or many of the prepared infant foods, act favorably in a purely mechanical manner when mixed with milk. The following method is highly recommended by Jacobi and Rudisch: Add together one pint of water, 3 ss. acid. hydrochlor. dil., and one quart of milk; boil for fifteen minutes, stir well; pepsin may be added when the milk is given. This preparation is easily retained by weak stomachs in cases of anæmia, gastric ulcer, or catarrh, and slow convalescence. The addition of a little sodium chloride improves the digestibility of milk. Milk is often advantageously given in combination with meat broth.

In cases of carcinoma of the stomach patients are sometimes able to live comfortably for a time on a fluid diet, consisting chiefly of milk. Oppolzer recommends sour milk in such cases as being less liable to form hard curds. It is better, however, to peptonize the milk. This is done by adding one of the numerous preparations of pepsin to the milk, and allowing it to stand in a bottle placed in hot water. A fermentation results in which the milk proteid is more or less completely converted into peptone. Further change is then checked by either boiling the milk or putting it upon ice until ready for use. Preparations of pancreatin are used in the same manner.

In "*forced feeding*" in phthisis, melancholia, etc., milk is very serviceable. If there is much catarrh, it is advisable to first wash out the stomach, and then inject a litre or so of milk through an œsophageal tube. In phthisis and various chronic febrile conditions, there seems often to be an increased nitrogenous metabolism, and the greater preponderance of proteids, as compared with hydrocarbons, in milk makes this food particularly beneficial.

Milk is employed as a prophylactic against lead-poisoning among type-founders, etc. It is claimed (Hirt) that if a litre and a half be drunk daily, the poisoning never occurs. Attempts to pass milk into the body, by rubbing it into the skin, have proved of no avail.

Milk has been sometimes used as a soothing lotion in conjunctivitis, and as a warm injection in chronic dry nasal catarrh, but it is not recommended.

As a *vehicle* for the administration of many medicines—insoluble powders, disagreeably-tasting drugs, etc.—it is very valuable. It is a convenient medium for giving rectal medicines.

The *intra-venous injection* of milk has been successfully employed in man. It was first tried by Hodder, of Canada, in three cases of cholera collapse, two of which recovered. It has been successfully used in post-partum and traumatic hæmorrhage. The operation is conducted in the same manner as the transfusion of salt-water (see article Transfusion).

Milk has also been injected into the *peritoneal cavity*. It has been given hypodermatically in doses of 4 Gm. in caries of the vertebræ (Menzel, Perco), and other diseases where the digestion was enfeebled. One patient was kept alive sixty-eight days in this manner (Whittaker). Exceptionally, abscesses have followed the hypodermatic use of milk. The injected milk is all absorbed in twenty-four hours.

Milk is frequently employed in *nutritive enemata*, alone or with beef-juice, beef peptonoids, spirits, etc. From one to two or more ounces are given at a time, after cleansing the rectum. A little laudanum may be added, and a towel should be held against the perineum to aid in the retention of the milk. Where the circumstances admit, it is advisable to pass a long catheter and inject the milk through it as far as the sigmoid flexure, while the patient is supported upon the hands and knees. The higher up the milk may be injected, the more readily is it absorbed, and the circulation of the rectum is such, that whatever ingredients of the milk are taken up by the venous capillaries of the lower portion pass to the vena cava, whereas the ingredients absorbed by the superior hæmorrhoidal vessels, or the sigmoid vessels, are carried quite directly to the vena porta and liver, where they are assimilated more promptly. The lymphatic capillaries also assist in the absorption. (See art. Intestine, Anatomy of Rectum, vol. iv., p. 173.)

The simple mucous secretions of the rectum have no proper digestive action upon milk (Czerny), but they may sometimes cause putrefaction of its albuminous matter, with formation of tyrosin, indol, etc. (Marckwald). It, therefore, facilitates the absorption to have the milk previously digested by pepsin or pancreatin. Patients with ulcer or carcinoma of the stomach, or with any intestinal obstruction, or with irritant vomiting, may be kept alive for many weeks by the exclusive use of nutrient milk enemata.

An *exclusive milk diet* (in health) gives a greater bulk of fæces than an exclusive diet of roast-beef or of eggs (Rubner). In such case there is a marked loss in the fæces of the salts of lime which have been contained in the milk. Four thousand grammes of milk ingested by the mouth are said to yield less than one hundred grammes of fæces (Rubner), so that in health the consumption of milk is very complete.

The *milk "cure"* has been carried out successfully by Pecholier, Weir Mitchell, Karell, and others. The patient is given no other food. Pecholier gives the milk every two hours in small amount, increasing the quantity until three litres a day are taken. Mitchell commences with doses of half an ounce to two ounces every two or three hours, and increases the quantity by half an ounce daily, until sixteen ounces are taken. If the taste of the milk is disagreeable, coffee, salt, or caramel is added. If thirst be complained of, natural or seltzer water is given. After three or four weeks, thin slices of white bread, arrowroot, rice, etc., are allowed, and after five weeks, raw meat or one or two cutlets. The milk meanwhile is continued. After a day or two of this treatment, hunger and thirst are usually not complained of. At first the pulse is increased a little in frequency; there is seldom any conspicuous nervousness. The tongue is coated; the water of the urine is increased; there is obstinate constipation (which must be relieved); the stools are hard and ochre or white in color, and a great deal of epigastric distress and feeling of emptiness are present. The arterial tension is lowered; there may be muscular prostration. There is loss of weight at first. If the treatment be persevered in, at the end of a fortnight there is marked improvement in the feelings and condition of the patient, and after six or eight weeks the cure is usually far advanced. The milk-cure is used in obstinate hysteria, hepatic congestion, dropsy, and various anomalies of nutrition. (For the use of the milk-cure in diabetes, see article Diabetes, vol. ii., p. 416.)

There are many *methods of adding to the nutritive value*

of milk, or of improving its taste for the patient. Such are *Milk punch*, made by adding brandy, whiskey, or rum to milk in the proportion of about one to four or six parts of milk, and flavoring with sugar and nutmeg.

Egg nogg, made by adding the beaten yolk of egg and a little spirits to a tumbler full of milk, stirring well, adding sugar and the white of the egg, separately beaten. The digestibility of both of these highly nourishing and stimulating preparations is enhanced by the addition of half an ounce of lime-water, which does not affect the taste.

For a description of the various preparations of milk in broths, gruels, custards, weak teas, milk-toast, porridges, with dried flour, etc., the reader must be referred to special works upon dietetics. By familiarity with a variety of such preparations, it is often easy to persuade an invalid to consume large quantities of milk, which would be refused if the milk were offered alone. Milk may be agreeably given boiled with chocolate or cocoa, and in the form of ice-creams, etc.

Where milk in large quantity is poorly digested, it may be well borne if given in teaspoonful doses every quarter or half hour. This prevents the formation of large indigestible curds in the stomach. It is customary, in hospital fever diets, to allow at least half a litre of milk per diem, and two quarts or more where milk is exclusively used.

There are a great variety of infant foods, such as Liebig's, which are intended to be added to milk to improve its digestibility or to give additional nourishment. (See article Infancy, Artificial Feeding, vol. iv., p. 15.)

The *principal varieties* and the several parts of milk, which are in common use, are: Boiled milk, skimmed milk, cream, curds, cheese, whey, butter, butter-milk, condensed milk, koumiss.

In the United States, according to the census of 1880 ("Tenth Census; Agricultural Statistics," p. 16), the milk employed in factories or "creameries" for the making of butter and cheese, amounted to 530,129,755 gallons. The butter produced amounted to 806,672,071 pounds, and the cheese 243,157,850 pounds. Milk otherwise used, 217,922,090 gallons. This is exclusive of much larger quantities produced on private farms, etc.

Boiled milk exhibits a thin scum of albumen upon the surface, which is quickly replaced by another after removal. There is much discussion as to whether infants should ever be given raw cow's milk, or only that which has been previously boiled, and authorities are divided upon the matter. Certainly in many cases raw milk provokes no harm. Boiling the milk arrests the development of germs and fungi, with which it may have become contaminated, and may thus prevent the spread of certain diseases; and it retards the process of "souring" and coagulation. Boiling expels about three per cent. of gases, C, N, and O (Hoppe), and the loss of oxygen diminishes the formation of lactic acid and consequent souring. It alters the taste of the milk somewhat, and makes it "flat." Some patients are made bilious and constipated by its use. A swallow or two of hot milk sometimes aids in coughing up tenacious mucus.

Skimmed milk is the residue after removal of the cream. It contains water, 90.63 per cent.; proteid, 3.06 per cent.; fat, 0.79 per cent.; sugar, 4.77 per cent. It is well borne by delicate stomachs which cannot take fat. It is employed in the milk-cure for Bright's disease, dropsies, etc., and in the treatment of neurotic hysterical cases.

Cream is the fat of milk which, by virtue of its light specific gravity, floats to the top of vessels in which milk is allowed to stand for some hours. The globules collect in a yellow film of varying thickness. The rise of the cream is retarded by coagulation, favored by a cool temperature and by the richness of the milk. It is best obtained by placing the milk in broad, shallow pans. The fat consists of glycerides of stearic, palmitic, myristic, oleic, butyric, and soluble fatty acids. Churning the cream causes the globules of fat to coalesce in small lumps and form butter. It is a popular fallacy that a little warm water added to milk increases the cream. It lessens the specific gravity of the milk and hastens the floating of the globules, but the ultimate quantity of cream is not affected. If the cream falls below five per cent. of the volume of milk, the milk has been watered. The normal average is over eight or nine per cent. The cream may exceed twenty per cent. The breed, age, and feed of the cow have a marked influence upon the amount of cream. The Alderney milk is rich in fat. Long-horns give more casein. Devonshire or clotted cream is solid. It is collected from milk previously heated to simmering.

The milk which comes from the cow toward the end of milking contains more cream than that which is first given. This is said to be due to the rising of the fat in the gland. This fact should be borne in mind by those who send for milk drawn in a separate small vessel direct from the cow. Afternoon milk is richer than morning milk in both proteid and fat.

Violent exercise, and in woman violent mental emotion, are injurious to the milk.

An ingenious process has recently been employed for rapidly obtaining cream from milk, by centrifugal force. A small and large drum are placed one within the other, leaving a space of some inches between. The inner drum is made of porous material. It is filled with milk and set in rapid revolution. The lighter cream remains in the inner drum, while the other solid ingredients are thrown with such force against the porous wall that they are forced through into the outer drum. It is claimed that the cream is more thoroughly separated in this manner than when it is allowed to rise on standing; and the process is exceedingly rapid.

In cooking, suet is sometimes added to replace cream, and impart additional color and flavor. Cream is used in various ways in the treatment of infantile disorders of digestion, marasmus, etc. (see Infancy, Artificial Feeding, vol. iv., p. 15).

Cheese is the separated casein of milk, which includes some of the fat and salts. There are many varieties, prepared in various ways. It forms a highly nutritious article of diet, and an important article of commerce.

In countries where meat is scarce and dear, the peasantry consume large quantities of cheese to supply the nitrogenous elements of their diet. They use for this purpose the heavier, less highly flavored cheeses.

The wealthier classes use cheese more as a condiment, taken after meals, and therefore they require higher flavored cheeses, which please the palate and excite the secretion of gastric juice. Taken in moderation, such cheeses are an aid to digestion.

Cheese is rich in fat and in flavor, according as it is made from whole or skimmed milk. Cream cheese contains about sixty-seven per cent. of fat. The highly flavored Roquefort, Edamer, Cheshire, Emmenthaler, etc., cheeses contain a similar quantity.

Cheese is usually prepared from sweet milk. The coagulation is accomplished in a few minutes by addition of rennet, with gentle heat (50° C.). The heat secures firmer coagulation. Casein may also be coagulated by acids. A little salt is added; the curd is strongly pressed in a mould (to squeeze out the whey), salted, and dried on the surface by frequent turning in the air. The harder cheeses are made under higher temperature and pressure. The cheese is then kept for a time to ripen, by fermentation or decomposition. If the decomposition goes too far, it develops leucin and tyrosin. The casein may become soluble in water, producing soda albuminate and peptones. The "riper" the cheese the greater the flavor and value as a condiment.

During the ripening, volatile fatty acids are evolved from the fatty matter present, which occasion the odor and flavor. The casein also undergoes change, and is partially converted into fat (Foster). It may putrefy and evolve ammonia, or even become poisonous.

Cream cheese is fresh, and not ripened.

Pot cheese is eaten fresh after the whey is pressed out. It contains: water, 60.27 per cent.; casein, 24.84 per cent.; fat, 7.33 per cent.; ash, 4.02 per cent.; milk-sugar and lactic acid, 3.54 per cent.

The *quality of cheese* depends upon the richness of the milk in fat. In the richest cheeses, Stilton and double Gloucester, cream is added. Cheshire, American, and similar cheeses are made from milk from which the cream has been removed. Dutch, Suffolk, and Parmesan cheeses are also made from skimmed milk. These latter varieties keep well, and become hard enough to be grated. Fatty matter makes cheeses soft, friable, and rich, but they soon decay. Toasted cheese is one of the most indigestible articles of diet.

Certain low organisms, moulds, fungi, etc., flourish in cheese and may make it very irritant to the stomach. Such are the aspergillus glaucus and sporendoneum casei, both of which give a red color; the cheese mite, or acarus domesticus, and the maggots of a fly, piophila casei. Bad cheese has been known to develop poisonous symptoms resembling those of poisoning by sausage-meat. From similar causes ice-cream has been known to become extremely poisonous, when infected cream was employed in its manufacture.

The milk first secreted after parturition (colostrum) contains more albumen than casein. It is viscid, turbid, frothy, yellow, and alkaline, and coagulates on boiling. In the cow the colostrum has a sickly odor and is purgative. It remains so for about a month after parturition.

Whey is the portion of milk remaining after the curds have been removed to make cheese. It contains albumen and fat in small amount, with most of the salts and sugar, which latter is partly converted into lactic acid. It is opalescent, and contains: water, 93.3 per cent.; milk-sugar, 4.65 per cent.; fat, 0.25 per cent.; proteid, 0.82 per cent.; lactic acid, 0.33 per cent.; salts, 0.65 per cent. It forms spontaneously when milk is allowed to stand for some hours. Whey is employed as a drink in fevers. It is sudorific, and by virtue of its salts and water it acts as a diuretic.

The *whey "cure"* consists in giving large quantities of whey at regular intervals, combined with easily digested food. It has been employed in the treatment of Bright's disease, gastric catarrh, etc. It is said to relieve irritant cough, and to improve the secretion in chronic bronchitis. It increases the strength of the pulse (May).

Not over five hundred grammes need be taken daily. More than this (and often less) increases peristalsis and gives watery stools, with colic and diminished appetite. The whey-cure is employed especially in Switzerland and Germany, where it is often combined with the grape-cure.

Butter is made from cream by the mechanical rupture of the albuminous follicles which enclose the fat-globules. The globules then adhere together into small masses. The rupture is accomplished by churning, and after the butter is of sufficient density, salt in small amount is added and the butter is "worked" over with a spatula and frequently washed. Perfectly fresh butter without salt is comparatively tasteless and keeps poorly. The decomposition of its nitrogenous matter liberates a ferment which separates fatty acids and glycerine. Butter contains six neutral fats, four of which, being volatile, give to it taste and odor (Chevreul). Fermented or "rancid" butter causes violent gastric derangement. Butter should have not less than 0.5 to 2.0 per cent. of salt, nor more than 8 per cent. Butter is adulterated by dealers by beating it up with water, and by adding other fats, especially suet and oleomargarine.

Butter which contains too much water, and too many ingredients other than the fat, has not been sufficiently "worked," and is liable to become rancid. An ingenious process for making rancid butter sweet again has been recently employed in California. The butter is melted in a tub, and the poles of an electric battery, encased in flannel, are placed in it so that a current of electricity, when passed through the butter from one pole to the other, determines a collection of the acids causing the rancidity at one or the other pole. In striving to reach the pole the acids soak into the flannel and may be then removed.

Butter will not support life for any considerable length of time when taken alone. Carnivora fed upon an exclusive diet of meat and fat do not grow fat, therefore the original Banting treatment has been modified, by Ebstein and others, by the free addition of butter to the diet. Taken in connection with other foods, however, butter is a highly digestible and nutritious, and often fattening, food.

An average sample of good butter contains: fat, 11.7 per cent.; casein, 0.5 per cent.; milk-sugar, 0.5 per cent. (König).

In weak stomachs the digestion of butter is improved by spreading it thoroughly in thin layers upon bread, or allowing it to soak into hot toast. It is thus prevented from floating about in a scum, which coats the walls of the stomach and retards gastric secretion (Brunton). The stability of butter is increased by repeated washings as it is shaped; by the addition of twenty to twenty-five grammes of salt per kilo; by melting it down with boiling water—after which latter process it is called "smalt;" by exclusion from the air; by keeping it under fresh water which is daily renewed; by the addition of weak tartaric acid (Brion, Payem).

Butter-milk is the portion of the milk remaining after the fat has been removed by churning. It contains albumen and finely coagulated casein, salts, water, and sugar, which is largely converted into lactic acid. It is of considerable nutritive value, and its peculiar taste is highly esteemed by some. It should be drank fresh, as it soon decomposes. In those disorders in which the digestion of peptones and of fats is poor, it is often easily borne. It is of especial value in chronic gastric catarrh with atrophy of the gastric glands (Eulenberg). Butter-milk contains less fat than skimmed milk. It is a favorite beverage with many persons. It is often fed in large amounts to swine. A butter-milk "cure" is sometimes practised after the manner of the whey-cure.

Condensed milk is prepared by slowly evaporating the water of milk by moderate heat. There are two varieties: the "plain," which is condensed to about one-fourth of its bulk and superheated, and to which little or no sugar is added; a stronger, more condensed sort, to which cane-sugar is added in excess. Such milk yields about thirty-nine to forty-eight per cent. of sugar among its solid ingredients. Sometimes as much as seventy-five per cent. is added. The sugar prevents decomposition, and when the condensed milk is put up while hot in hermetically sealed cans, it will keep fresh for years. It will even remain fresh for several days after a can is opened. It is readily soluble in water, to any degree of dilution. Condensed milk is largely used for the nourishment of infants, especially among the poorer classes. They thrive on it for a time, but although they appear fat their flesh is less firm, and they develop poorly, and are less able to resist disease. This milk, when diluted, readily undergoes lactic acid fermentation, and causes diarrhœa, thrush, etc. Condensed milk has been used with advantage in the treatment of dysentery (Heubner), and as a prophylactic against scurvy. Milk may be preserved for some time in hermetically sealed cans or bottles without previous condensation, but a separation of the cream takes place, and butter forms in the can.

Koumiss, Kumys, is fermented milk prepared in a peculiar way. It is used by the natives in the steppes of Southeastern Russia as a refreshing and mildly intoxicating beverage. It is also used in the treatment of phthisis, chronic bronchitis, chronic gastro-intestinal catarrh, and other wasting diseases; but probably a large part of the benefit of the native koumiss "cure" is due to the favorable climate in which the patients live. There are many ways of preparing koumiss. The milk of a certain breed of mares is used, which contains a very large percentage of milk-sugar, but is poor in fat and casein (Spassky). The mares are carefully fed upon grasses rich in sugar-forming material (Karrik). The best koumiss is made in the early summer months. The milk is put into smoked-out leather bottles or "sabas," and sour cow's milk, or old dried koumiss, is added. The skins are kept warm and are frequently shaken. In three or four days the fermentation is completed. Sometimes an artificial ferment is used, and this is the case where kou-

miss is made from cow's milk in this country. Such a ferment may be prepared with flour, wheat, honey, and beer yeast. The importance of absolute cleanliness in all the manipulation is insisted upon, else putrefaction results. Koumiss foams when shaken, it has a sour taste and odor, and an acid reaction with a specific gravity of 1.018 to 1.029. The milk-sugar forms in part galactose and alcohol. There is two and a half per cent. of alcohol present. The albuminates of the milk are converted into peptones. The casein is at first precipitated, and then changed to acid albumen and peptone (Dochmann). The composition of koumiss is constantly changing. It becomes daily more sour, and it keeps poorly when exposed to the air. In the koumiss-cure from fifteen to twenty glasses are drunk daily, combined with nourishing food. It is best taken warm, in small quantities at frequent intervals. Fresh koumiss is apt to cause flatulence, colic, and diarrhœa. Old koumiss may cause constipation. Koumiss is strongly diuretic and also diaphoretic; it thus relieves the mucous membranes of congestion. Koumiss quenches thirst, increases the cardiac force, and improves the vascular tone, general nutrition, and the complexion.

Koumiss is said to be contra-indicated in renal and vascular diseases, and plethora. The koumiss which is prepared from cow's milk is useful in some cases of irritant vomiting, summer diarrhœa of infants, etc., but it does not seem to possess the extraordinary nutritive value of the Russian article. It is made fresh from cow's milk by various firms in the United States, and preserved in glass bottles.

The *quality* of milk depends upon the breed and proper feed and care of the cows. Absolute cleanliness in its handling is necessary.

At some dairies the milk is put directly after milking into glass bottles, which are then tightly corked. If pails and pans or cans are used, their absolute cleanliness must be insured by frequent careful washing, and by occasional scalding with hot water. This destroys germs or ferments which would otherwise contaminate the fresh milk and soon sour it.

Many large dairies now employ a physician, whose duty it is to daily examine all the cows and report on their health, and on the hygienic condition of the stables, yards, etc. Cows fed on brewers' swill, or cows allowed to eat decaying autumn leaves, or garlic, cabbage, or certain injurious meadow plants, or strong-smelling plants, like cabbages, turnips, and onions, will give unhealthy, strong-smelling, or deteriorated milk. Insufficient diet impoverishes the solid ingredients of milk very quickly. The possibility of tubercular or scrofulous infection from drinking the milk of cows with "pearl disease," which is believed to be analogous to tuberculosis, has been suggested. The lower animals can be thus infected, but there are no authenticated cases of human infection through this medium. It is well for physicians to consider the question further, and certainly the milk of such animals is below the proper nutritive standard.

The *color of milk* is affected by various ingested substances and by germs. Thus madder colors it saffron (see effect of drugs, below). The oïdium lactis, or penicilium (Parkes), and bacterium cyanogeneum are germ-growths which produce a blue color in milk. This color appears first upon the surface if the milk be not agitated, and it differs from the uniform blue imparted by adulteration with water, or by poisonous plants, drugs, etc. Milk thus affected is irritant, and may induce febrile gastritis, aphthæ, etc. Milk is colored yellow by the bacterium synxanthum (Ehrenberg), and red by blood (rarely), and by chromogenic fungi. The fungi and germs do not themselves give the color, but they develop various anilines, aniline blue, fuchsin, etc., from the casein, which occasion the color (Schröter). Mucous fermentation of the proteids makes the milk slimy, and it becomes stringy on boiling.

Milk is apt to acquire a strong odor from substances kept in its vicinity. Its absorbent power is considerable.

The *foot-and-mouth disease* of cattle is transmitted to man if the milk of cows so affected be drunk without boiling, which destroys the germs (Bollinger). This disease is transmitted even when the milk is diluted ten times, or taken in coffee or tea. But adults must drink a good deal of it in order to become affected. Butter and cheese made from such milk also carry the infection (Schneider). The foot-and-mouth disease diminishes the quantity of milk given by the cow to one-half, and the milk coagulates too quickly, and has a yellowish colostrum-like appearance. If the disease be severe the milk separates into slimy coagula and whey, and on boiling curdles in stringy masses. In other cases the taste is acid, and on standing twelve hours a yellow sediment precipitates with a nauseous, rancid odor. The milk becomes infected from sores upon the teats.

It is believed that syphilis is not conveyed through human milk, though the infant may become infected through abrasions of the nipples (Lee, Baumler).

For *transportation* from the country to the city, milk is usually taken from the farms in forty-quart tin cans, which should be filled full and tightly covered to prevent churning and souring. Some railways supply refrigerator milk-cars which are hung upon especially constructed springs, to prevent, as far as possible, agitation of the milk in the cans.

The *prevention of adulteration* of milk is a matter of vital importance from both an economic and hygienic standpoint. Children, who are so largely dependent upon milk, do not well tolerate its adulteration.

The *inspection* of milk, in all large cities and towns, is made at the ferries and railway stations where the cans are received. The examination is under the direction of special officers, usually members of the local health board. It is impossible and unnecessary to examine all the milk brought in, but the officers make frequent seizures, and destroy at once all milk found below the legal standard. Milk sold in shops, and otherwise, must also be frequently examined, for its dilution and adulteration is very easy and profitable to the unscrupulous. The commonest method of alterating milk is by simple dilution with cold water in varying amount. In some cases, to thicken it again and to prevent its looking too pale and blue after water is added, flour or chalk or other ingredients are put in. Sodium bicarbonate and salicylic acid are added to prevent "souring." The examination of milk requires the adoption of a legal standard of quality. The milk is tested for its specific gravity by an instrument called a "lactometer," or "araeometer," and for its cream by a "creamometer." In New York the Health Board depend chiefly upon the use of the lactometer. In other States, such as Massachusetts, Rhode Island, Maine, etc., a chemical analysis is required by law. The normal average specific gravity allowed is 1.030+ (in New York 1.029+) and the normal average amount of cream is 8+ per cent. by volume.

In 100 parts of milk there should be (Wanklyn):

Fat	3.20	Solids not fat: Ash	0.60
Solids not fat	9.30	Sugar	4.40
Water	87.50	Casein	4.30
	100.00		9.30

A *lactometer* is a spindle about 15 ctm. long, which readily floats in a quart measure. It is graduated from 0 (the water-line) to 40°. Milk in which it floats at below 29 is pretty surely watered, or, if it floats above 33, the milk is skimmed. The specific gravity of the milk being taken, the amount of dilution is easily computed by comparing it with the standard 30. Suppose it to be 21 in a given case, then 30 : 21 :: 100 : 70. That is, only 70 parts per 100 of the sample are milk, and 30 parts of water have been added. To facilitate the calculation the space between 0 and 40° may be divided into 100 parts, each division of this second scale represents 1°, or one per cent. of milk. Thus, if the lactometer stands at 50 of this second scale, there is only fifty per cent. of milk in the sample. There has been much dispute regarding the value of the lactometer, on the ground that an excessive amount of cream, on account of the lightness of the fat, diminishes the specific gravity of a really rich milk. On the other hand, it is claimed that the diminished gravity

is always due to increase in the quantity of water, and that milk rich in cream will also contain less water, and therefore maintain the normal standard. The matter has been tested in the courts, and in New York the lactometer test alone is always sufficient to insure conviction in cases of adulteration of milk with water.

Sometimes, in estimating the specific gravity, acetic acid is first added to precipitate the casein, which is removed with the fat; the specific gravity of the whey is then taken. Hassall claims that the latter is more constant than the specific gravity of milk itself.

The *total quantity of solids* in milk should amount to fourteen per cent. (Letheby).

To estimate the total amount of solids in milk various tests are employed. A common method used by health boards is to weigh and evaporate 5 c.c. of milk to dryness in a small, flat-bottomed, platinum crucible, of a known weight. This takes about an hour. The residue is then dried for an hour more at 100° F. and weighed. The milk dries in two layers. The upper layer consists of a thin skin of fat, which is dissolved in petroleum benzine. The lower honeycombed layer is then washed and dried and weighed again. The loss in weight after removing the upper layer represents the amount of fat. The soluble salts and soluble proteids are then dissolved out by warm water and alcohol, and separated from the insoluble salts and proteids. Ignition over a Bunsen burner drives off all the organic matter and leaves the ash, which is again weighed. To estimate the amount of cream, the sample of milk is allowed to stand in a cool place for twenty-four hours in a "creamometer." This is a simple glass tube, 25 mm. wide, and 25 ctm. deep, which is graduated in hundredths from above downwards. It is filled with milk to the zero level. The cream rises to the top, and the percentage per volume is easily read off.

The richness of the milk in cream, or its dilution with water, may also be measured by its opacity. Five c.c. of milk added to 100 c.c. of water are placed in a glass cell, called a "lactoscope" or "diaphänometer" (Donné), with parallel sides, through which a candle placed at a distance of a metre may be seen. More milk is then added, drop by drop, until the opacity of the cell-contents obscures the light. This method is more tedious and less accurate than the other. Cream varies in specific gravity between 1.010 and 1.024.

The method of *quantitative estimation of milk-sugar* is the same as that employed for glucose in the urine (see art. Urine, Examination of). The casein is first precipitated by acetic acid. The whey is filtered and tested with Fehling's copper solution, or with a polariscope. Convenient tables are made out to facilitate the calculation.

A *great many drugs* are excreted through the mother's milk, and it is often the case that an infant is affected by sucking such milk. It is possible to act upon infants through this medium, but the strength of dilution in which the drug reaches them is far too uncertain. An infant has been killed by nursing from a mother who had taken an overdose of laudanum (Fletcher). Acids given to a nursing mother may cause colic in the child. Neutral salts loosen the bowels, and potassium salts act as diuretics for infants when taken by the mother. Aromatic oils, and probably all volatile oils, are found in the mother's milk. The agreeable taste of some of these substances causes the child to suck harder, and cause thereby a reflex stimulation of the mammary glands to further secretion.

Among the substances which have been determined in the mother's milk after ingestion by the stomach are: senna, rhubarb, scammony, sulphur, castor-oil, ammonium salts, turpentine, copaiba, anise, dill, garlic, wormwood, and jalap. Vegetable acids give rise to CO_2 in milk. If nursing mothers partake freely of fresh fruit and green vegetables, their milk may gripe and purge their infants. Antimony passes readily into mother's milk, and should be given with caution to nursing women. Potassium iodide, corrosive sublimate, and other mercurial salts, arsenic, zinc, and lead, all pass into the milk, at periods varying from four hours to several days after their administration, and continue to be excreted for a day or two after the drug has been withheld.

Milk is colored red or yellow by rhubarb (Mosler), and it is colored blue by some drugs and some kinds of cow's feed. The color is then uniform throughout the milk, and not superficial as in the case of the blue color imparted by the growth of fungi described above.

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William Gilman Thompson.

MILK, PHYSIOLOGICAL AND PATHOLOGICAL CHEMISTRY OF. *Colostrum* is the name that has been given to the milk secreted immediately after the birth of the child. It is a turbid, somewhat yellowish fluid, in which the so-called colostrum-corpuscles abound, and in which few of the ordinary milk-globules are found. It has an abundance of albumen, as is shown by its coagulating on heating—which ordinary milk does not—but has very little if any casein, a little fat, milk-sugar, and salts. It changes gradually so as to acquire the characters of ordinary milk.

Milk is an opaque fluid, in color varying from bluish-white to white or yellowish-white, containing milk globules of 0.01 to 0.0015 millimetre in diameter, and much undissolved casein, to which, in part, the turbidity of milk is due. The milk-globules consist of fat (butter), with a little cholesterin and lecithin. Whether these globules have an albuminous envelope or not is undetermined. The question as to the reaction of milk has been much agitated, and differences of opinion still prevail. This is in part explicable by the fact that milk contains NaH_2PO_4, which has an acid reaction, and also Na_2HPO_4, with an alkaline reaction. When milk is boiled it becomes more alkaline.

The *cream* of milk consists of the aggregated fat-globules, which, being specifically lighter, naturally rise to the top of the fluid when it remains quiet. When the globules are still more closely aggregated they form butter.

Buttermilk differs from ordinary milk in being poorer in fat, having a less alkaline or an acid reaction, and coagulating on boiling.

If milk be allowed to stand before or after being deprived of its cream, it undergoes certain changes in consequence of the presence of a ferment. It separates into clot and milk-serum or whey.

The milk ferment changes sugar into lactic acid, which separates casein from its alkaline combination (Kapeller). The same result may be effected by the gradual addition of a dilute acid to fresh milk, especially at blood-heat. A similar change is produced by rennet, a ferment which, according to Hammarsten, produces some change in the casein itself. If a casein solution with no calcium phosphate present be subjected to an infusion of rennet, no coagulation takes place.

It has been observed that milk will sometimes, on standing, deposit little or no cream. This Pasteur attributes to a sort of micrococcus which acts on milk-sugar. Milk may be obtained free from fat and casein by filtration through porcelain under increased pressure, when it appears as a clear fluid like water. Hoppe-Seyler obtained milk almost or wholly free from casein by filtration through animal membranes. Kehrer maintains that casein is not dissolved in the milk, but only swollen.

THE INDIVIDUAL ELEMENTS OF MILK.—*Casein.*—This substance is peculiar to milk. When prepared pure it is a very fine, snow-white powder, giving no ash on burn-

ing. It may be heated to 100° C. after careful drying, without change. It is almost wholly insoluble in pure water, but reddens moist blue litmus paper. It is with difficulty soluble in acids, but easily soluble in carbonates and phosphates of the alkalies.

By rennet ferment it is split into two bodies, of which one in the presence of calcium phosphate becomes cheese, and the other remains dissolved in the fluid. The latter gives the reaction of peptone, but seems to have a different composition. To this the term whey-albumen has been given.

Human casein is but imperfectly, or not at all, precipitated by the rennet of the calf or by acids, but is separated by sodium chloride or Glauber's salts and heat (Biel); by a large excess of magnesium sulphate (Makris), and by tannin and alcohol.

Mare's casein is said to resemble that of the human being.

Casein consists of C, H, O, N, S, and P. The phosphorus exists in the form of nuclein, or, according to Hammarsten, as nucleo-albumen, in which the nuclein forms part of the molecule. Casein turns the plane of polarization to the left.

The Origin of Casein. As casein has not been found except in milk, it is probable that it originates solely in the milk-glands, and is derived from the albumen of the blood.

Other Albuminous Bodies in Milk.—When milk is heated to from 60° to 70° C. a flocculent precipitate is formed, which is probably identical with the serum-albumen of the blood. When this is filtered off, other albuminous bodies may be found in the fluid. These are lactoprotein (Millon and Commaille), galactin (Morin), and albuminose (Bouchardat and Quevenne). These bodies show properties very like those of peptone, and some writers maintain that they are identical (Ssubotin, Kirchner). According to Hammarsten, there is also a globulin present.

Milk-sugar: $C_{12}H_{22}O_{11}$. This substance has so far been found only in milk, and in certain cases in the urine of woman during lactation. It may be obtained in large rhombic crystals, with one molecule of water; insoluble in alcohol and ether, but readily so in water.

The polarization, with water still in combination, is: $[\alpha]_j = +52.53$, at 20° C.

By heating to 130° the water is driven off. Heated with alkalies, like dextrin, it turns brown. It reduces alkaline solutions of copper sulphate. It does not undergo fermentation with beer-yeast, but with schizomycetes it produces lactic acid and alcohol (Fitz). Boiled with dilute mineral acids it is resolved into dextrose and galactose. When it is heated with nitric acid, mucic, saccharic, carbonic, oxalic, and tartaric acids and grape-sugar are formed.

Milk-fat. This substance, as found in cow's milk, has been accurately investigated. It consists of stearates, palmitates, oleates, and only about two per cent. of characteristic butter-fats (Bromeis).

The following is a complete list of the various acids found in butter: Formic, HCO.OH; acetic, $CH_3.CO.OH$ (traces, Wein); normal butyric, $C_3H_7.CO.OH$ (Grünzweig, Wein); normal caproic, $C_5H_{11}.CO.OH$ (Wein); normal caprylic, $C_7H_{15}.CO.OH$ (Wein); capric, $C_9H_{19}.CO.OH$ (Wein); myristic, $C_{13}H_{27}.CO.OH$ (Wein); palmitic, $C_{15}H_{31}.CO.OH$; stearic, $C_{17}H_{35}.CO.OH$; arachic, $C_{19}H_{39}.CO.OH$ (butic acid of Heintz); oleic, $C_{17}H_{33}.CO.OH$.

The fat of human milk is more fluid than that of the cow (Hoppe-Seyler).

The other organic constituents of milk are: lactic acid, traces of alcohol, traces of urea, lecithin, cholesterin, hypoxanthin.

The following table shows the amounts of gases found in two samples of one cow's milk (Pflüger).

	Per cent.	Per cent.
O	0.10	0.09
CO_2	7.60	7.40 (pumped out)
CO_2	0.00	0.20 (driven out by PO_4H_3)
N	0.70	0.80

In One Hundred Parts Milk.	Dog (Poggiale).	Cow.	Goat.	Sheep.	Ass.	Mare.	Buffalo (Becquerel and Vernois).	Camel (Dragendorff).	Pig (Lintner).	Pig (Cameron).	Hippopotamus (Gimming).	Elephant (Doremus).
Water	73.41	85.71	86.36	83.99	91.02	82.84	80.64	86.24	82.93	81.80	90.43	66.69
Solids	26.59	14.29	13.64	16.01	8.98	17.16	19.36	13.66	17.07	18.20	9.57	33.31
Casein	13.04	4.83	3.36	5.34	2.02	1.64	4.25	3.67	6.89	5.30	4.40	3.21
Albumen		0.58	1.30				1.30					
Butter	8.18	4.30	4.36	5.89	1.26	6.87	8.45	2.90	6.88	6.00	4.51	22.07
Milk sugar	2.89	4.04	4.00	4.16	5.70	8.65	4.52	5.78	2.01	6.07	....	7.39
Inorganic salts	2.08	0.54	0.62	0.68			0.84	0.66	1.29	0.83	0.11	0.63

In One Hundred Parts Ash.	Woman's milk I.	Woman's milk II.	Dog's milk I.	Dog's milk II.	Mare's milk.	Cow's milk.	Rabbit.*	Dog.*	Cat.*
Potash (K_2O)	32.14	35.15	10.74	12.98	25.44	22.14	10.84	8.49	10.11
Soda (Na_2O)	11.75	10.43	6.13	5.37	3.38	13.91	5.96	8.21	8.28
Lime (CaO)	15.67	14.79	34.44	33.03	30.09	20.05	35.02	35.84	34.11
Magnesia (MgO)	2.99	2.87	1.49	1.66	3.04	2.63	2.19	1.61	1.52
Iron oxide (Fe_2O_3)	0.27	0.18	0.14	0.10	0.37	0.04	0.23	0.34	0.24
Phosph. acid (P_2O_5)	21.42	21.30	37.49	36.68	31.86	24.75	41.94	39.82	40.23
Chlorin (Cl)	20.35	19.73	12.35	13.91	7.50	21.27	4.94	7.34	7.12

* Sound young animal.

The first of the tables above given represents the analyses made by Gorup-Besanez, and the second those of G. Bunge.

Woman's Milk is distinguished from that of the cow by its bluish tint, and also by the fact that, when shaken with ether, it loses its opacity. It is generally alkaline in reaction.

The maximum of butter and albumen is found during the period from the fifteenth to the twentieth year of life, of sugar, from the twenty-fifth to the thirtieth, and of salts, from the fifteenth to the twentieth year (Vernois and Becquerel).

The following analyses of human milk are interesting:

In 100 Parts Milk.	Biel.			Brunner.*			Tidy.†
	Min.	Max.	Mean.	Min.	Max.	Mean.	Mean.
Water	....	....	87.60	....	....	90.00	86.27
Solid remnant	11.20	13.68	12.39	8.06	13.04	10.00	13.73
Casein	1.68	3.15	2.21	0.18	1.54	0.63	2.95
Albumen							
Fat	2.59	5.39	3.81	0.24	4.41	1.73	5.37
Sugar	5.79	6.61	6.09	4.65	6.93	6.23	5.14
Soluble salts	0.03	0.18	0.09	0.77	2.59	1.41	0.22
Insoluble salts	0.16	0.25	0.19				

* From six days to nine months after child-birth.
† Seven to twelve days after child-birth.

Most of the valuable work on the chemistry of milk has been done in Germany at the agricultural stations. A very good account of the result of the various researches may be found in the article by E. Drechsel, in Hermann's "Handbuch der Physiologie," from which many of the above facts have been drawn.

In America the analyses of *human* milk by Professor Leeds deserve special mention ("Transactions of the College of Physicians," Philadelphia).

T. Wesley Mills.

MILK-SICKNESS. A disease called by this name has been known in portions of North Carolina, Tennessee, Kentucky, Western Pennsylvania, Ohio, Michigan, Indiana, and around the groves in the State of Illinois.

It has probably never been known on any of the Western prairies, at any point west of the Mississippi River, in the New England States, the Canadas, in any islands, or in any part of the Old World.

It met the immigrants upon the first settlement of the sections above named,* and is probably not entirely eradicated in any of these sections to this day. Perhaps no medical journal has been published for any considerable length of time, in any portion of these infected districts, that has not contained reports of cases, or some article bearing upon the subject of this disease, by some of the more ambitious or enterprising among the country physicians; but in the cities of the eastern coast—where most of our medical text-books have been written—the existence of the disease has been ignored, or it has been regarded as merely a modified form of some other well-known disease, which has not been properly recognized under its modified or masked form.

My people became citizens of Central Ohio seventy-five years ago—among the first emigrants from New England or elsewhere—and several of them fell victims to the disease; and it has been familiar to me for over forty years—thirty-three years of which have been spent in the practice of my profession.

I regard the disease as a disease *sui generis*. I have met with the same set of characteristic symptoms here, in Ohio, along the valleys of the White and Wabash Rivers, in Indiana in 1854, and around the skirts of Indian Grove, in McLean County, Ill., in the same year.

In the lower animals the disease is called *trembles*—from the characteristic trembling of the muscles in the animal affected, especially when it is compelled to take exercise.

In the human species it is called *milk-sickness*—probably deriving this name from the fact that it was first recognized that the use of the milk and its products was the cause of the disease, before it became known that the flesh of an animal suffering from trembles, or in the prodromic stages of trembles, would also produce the disease, or it may have been that the aborigines gave this name to the whites; for it was a disease well recognized by such of the tribes as were found here by the whites when the country began to be settled.

Among domestic animals the trembles usually, or universally indeed, is first developed in the unweaned calves, colts, and lambs. This may be reasonably accounted for from the fact that the unweaned are subjected to a two-fold cause—the same cause that might occasion the trembles in the mother, added to the ingestion of the mother's milk.

The disease next affects the members of the herd that are not giving milk, and the milk-giving animals last of all. This partial exemption in the milk-giving animals may be accounted for by the partial elimination of the specific poison through the emunctories of the lacteal glands. For, whatever be the nature of the poison, it is *specific*. The milk, or the butter made from it, and also the flesh of an animal suffering from well-developed trembles, or in the prodromic stages of the affection, are liable to transmit the *specific* disease to the animal or the person partaking of them; the lower animals—as the dog, the cat, the hog, and the turkey-buzzard—partaking of the flesh of an animal dead of the trembles are liable and likely to become infected with *trembles;* and likewise, the person partaking of the milk, the butter, or the flesh of cow, wild deer, sheep, or other animal affected with the trembles, becomes liable to contract *milk-sickness*. The poison is *specific—producing that one disease and no other*.

Etiology.—As to the exact cause or causes of the disease, there are different theories advanced, each theory having its own advocates; but the real cause probably remains as much of a mystery to-day as it was in the early settlement of the infected districts.

First, there are the theorists who cling to the idea of ingestion, by the herbivora, of some injurious form of vegetation; second, those who attribute it to a deleterious water-supply; third, the marsh miasmatic theorists; fourth, those who attribute it to some *mineral* poison that has an affinity for moisture, and, rising with the dews, settles on and adheres to vegetation; or, rising with the dews, is taken in by inhalation; fifth, those who believe that its cause is *bacterial;* that *spores*, *bacteria*, or some microscopical *fungi* or *disease-germs* are taken into the system with either the food, the water, or the inspired air.

But in theorizing as to the probable causes some cardinal points should not be overlooked: 1. That, as a rule, it is a disease of dry seasons. 2. That in unusually dry seasons, and in localities where the disease is prevalent, it is known to be unsafe to allow domestic animals to remain in the infected districts through the night-time. 3. It has never been considered unsafe for animals to roam at will in the day-time, even in known infected districts. 4. In different enclosed fields, where the flora are supposed to be identical, the disease may become developed in the cattle grazing in one field, and not in those in another. 5. It is a disease unknown in the open prairies of the Western States, where domestic animals are not allowed to remain in the timber belts over night. 6. It is a disease, with occasional exceptions, of the late summer or the autumn months. 7. The pioneers found that by keeping domestic animals corraled in a "tame" piece of land, from before nightfall until the dews and fogs became dissipated on the following morning, there was almost, if not quite, a total exemption from the disease; and that the danger came from allowing stock to remain out in the timbers over night. The careful pioneer invariably had his corral on land near his house, where the land had become "tame." For the land to become "tame" it was only needed to denude it of timber and let in the sunlight to the surface of the corral. It was not necessary, probably, to plow and cultivate the ground, but this was sometimes done.

The cases of trembles that occur in winter are not so easily accounted for; but the pioneers generally attributed them to the use of hay cut from the wet glades or partially shaded "openings," that had never become "tame" by continuous pasturage or cultivation.

Trembles and milk-sickness were generally hard to locate by strangers in the particular "settlement," as a "milk-sick farm" was not desirable as a place of residence, and if known to be such, was rendered almost unsalable. About the nearest a stranger ever got to one, if the settlers were to be believed, was, that it could be found over in another settlement; and occasionally it would be acknowledged that they sometimes had trembles "on the next farm!" But in point of fact, its home seems to have been in densely wooded, or brushy, unimproved tracts of country; and it seems to have been but little influenced by the variety of soil or the topography of the country.

* Nicolay and Hay, in the opening chapter of their History of Abraham Lincoln (Century Magazine, November, 1886), refer to this disease in the following terms: "In the autumn of 1818, the little community of Pigeon Creek was almost exterminated by a frightful pestilence called the 'milk-sickness,' or in the dialect of the country 'the milk-sick.' It is a mysterious disease, which has been the theme of endless wrangling among Western physicians, and the difficulty of ascertaining anything about it has been greatly increased by the local sensitiveness, which forbids anyone to admit that any well-defined case has ever been seen in his neighborhood, 'although just over the Creek, or in the next county, they have had it bad.' It seems to have been a malignant form of fever—attributed variously to malaria and to the eating of poisonous herbs by the cattle—attacking cattle as well as human beings, attended with violent retching and a burning sensation in the stomach, often terminating fatally on the third day."

I know, as all my neighbors know, of a few pieces of woodland within five miles of where I live, that have been, and now are, the homes of "trembles," and a dry season has never occurred, since the settlement of the country by the whites, in which it would have been safe to have kept there any of the domestic herbivora during the dry months of summer and autumn; although through the winter and spring months the fields have generally been occupied with perfect immunity from the disease. These tracts of land are kept for the timber-supply for the farms; but in some of them the negligent owners have lost enough stock with trembles, by allowing the fields to be occupied too late in the summer, to make their experience very dearly bought.

Predisposing Causes.—Perhaps the most marked predisposing cause is *fatigue*. And this fact has been a matter of good fortune to the shipper and consumer. Among the stockmen of Central Ohio, in pioneer days, one of the stipulations in a trade for cattle, horses, or sheep, was the privilege of chasing the animals for a stipulated time. If they had trembles, or were in the prodromic stages of trembles, they would soon "show signs." And, if by the following morning they were found active and "in good spirits," a bargain could be concluded. They sometimes "gave down," or "showed signs," with brief, moderate exercise; so that there was little or no danger of their being unsound if they did not exhibit any of the characteristic symptoms of disease before reaching a market.

Another well-recognized predisposing cause was giving domestic animals too much *salt* at one time. This might have arisen from the irritating effects of the salt on the stomach; or from the secondary effect of causing them to drink too much water.

Period of Incubation.—That this is an incubative disease, I have no doubt. And, from what data I can gather, I should estimate the period at from eight to twelve days; although I knew one case of milk-sickness, several years ago, which seemed to be clearly traceable to butter spread on bread, and eaten only two days before the prodromic stage became pretty fully developed. The most of my data come from the fact that many of my cases have acknowledged that, from one to two or three weeks before they became sick, their milch-cows had gotten out of their pasture and had "stayed out" in some wild, wooded land one, two, or three nights. And usually, when a milk-sick case is met with, if the calves have not yet shown "signs" of trembles, a little violent chasing around the barn-lot will soon develop them.

Symptomatology.—In speaking of this subject I cannot well help repeating from a paper read by myself before the American Medical Association, in 1883.

In the lower animals the disease is called "trembles"—from the agitated condition of the muscles in the animal affected, after the case has become fully developed.

The first symptom of the disease that is generally noticed, is that the animal is indisposed to exercise. It stands apart from the herd, drooping, indifferent, and listless—persistently abstaining from food.

The trembling stage comes on later, but may be fully developed in a short time by forcing the animal to exercise. Extreme thirst is present in most cases, and persistent constipation in all cases. As the disease progresses the animal declines to stand up; and when it lies down it seldom rises again. The least exertion brings on the trembling, which looks much like the trembling and twitching of beef immediately after the butcher has removed the hide from the killed animal. The decubitus, when once assumed, is at full length; and the animal becomes a stranger to any manifestations of fear, affection, or anxiety. The respirations become less and less frequent, the extremities and surface of the body cool, the nose dry, and the eyes at length glazed, and the winking finally ceases altogether. Recoveries are infrequent, and death usually ensues from the eighth to the tenth day. Violent exercise, as forced running or driving, will result in speedy death at any of the later stages of the disease.

In "milk-sickness" the patient becomes weary, indefinably weak, apathetic, and indisposed to any exercise, with loss of appetite, or loathing of food, and, in some cases, with slight nausea from the first. Occasionally these symptoms may run on for four or five days before the patient takes to his bed; and in some cases, which have been hurried up by overwork, or by other violent exercise, the fully developed stages may supervene within a few hours. There are *no chills*, *no rigors*, and none of the violent headaches that usually characterize the ushering in of severe or dangerous malarial fevers. There is usually an insatiable thirst; the tongue is large, flabby, tremulous, moist, and heavily loaded with a dirty-white coating. The nose and ears are cold to the touch, and a sensation of coldness is imparted to the touch from the whole surface of the body. The skin is dry, and sensible perspiration is suspended. The abdomen is flat, flabby, and comparatively empty. *Peristaltic motion seems absolutely suspended*, and the bowels are obstinately constipated. The breath becomes offensive, and some physicians and many laymen claim that they could detect milk-sickness in a darkened room, and blindfolded, by the characteristic odor of the breath alone. This, however, has always seemed to the author to be something of an exaggeration.

The urine is clear and limpid, and gradually diminishes in amount to eight or ten ounces a day. The pulse is weak and easily compressible, with labored action of the heart and strongly pulsating aorta.

The temperature is usually below normal; but in some cases may reach 99° or 100° F.

There is a characteristic hebetude and indifference; and in cases in which there seems to be no promise whatever of improvement, the patient seldom, or never, manifests any solicitude for his own future or for the future of his family or friends.

There is intolerance of covering for the body, even to the extent of complete indifference to the claims of decency.

The *nausea* is a very pronounced symptom: and as the disease progresses the retching declines—from the effects of the indescribable feebleness—until the sound produced by the effort becomes so peculiar that when once heard it will always be remembered.

If any fluid is expelled from the stomach in the later stages, it not infrequently resembles the blueing water of the laundry.

The hebetude at length assumes the condition of semi-coma; the respirations lessen in frequency, and become irregular, sometimes scarcely perceptible, but occasionally profoundly stertorous.

The process of winking lessens in frequency and regularity, until at length it becomes altogether suspended. The semi-comatose condition at length progresses to actual coma. The conjunctiva and cornea become glazed, and there is stasis in the capillaries. And without a moan or a struggle, and even without a sign, the impenetrable night is on, and the patient is at rest.

I have never but once seen anything like a crisis. This was in the case of a young girl, about twelve years of age. There were five cases of milk-sickness in that family. The father died on the eighth or ninth day; and the mother, who was *enceinte*, and three of the children, made slow and almost imperceptible recoveries. In the case of the twelve-year-old girl, I abandoned, on the tenth day, all expectation of recovery. On this tenth day, while in her coma, she had a dejection of about one quart, of the consistency of soft soap, and deep-green in color. The process of winking had been suspended for forty-eight hours, and scarcely any signs of vitality were left. Twelve hours later the almost imperceptible respirations had increased to five to the minute: and she had been noticed to open and shut her eyelids four or five times. She gradually recovered.

Pathology.—Of the pathology I cannot speak from personal experience of actual post-mortem observation. This may seem strange, and even inexcusable: but various causes have prevented me from ever studying the disease post mortem in the human subject, one of which is that these cases usually occurred in the "sickly season,"

at a time when no hour seemed to be spared to the overworked and exhausted country practitioner. I think the conclusion prevails, however, among the majority of those who have held post-mortem examinations, that there are sometimes, but not always, evidences of slight subacute inflammation, or at least congestion, of the mucous coat of the stomach; but, possibly, no more of this than would be excited by the continuous retching during the days of illness. In a post-mortem examination made on a calf, I discovered no evidence of an inflammatory process either in the stomach or in the bowels, and only an appearance of a general congestion of all the internal viscera.

I never saw a case of milk-sickness where tenderness was elicited by pressure over the stomach or bowels; nor have I ever heard any milk-sick patient complain of pain anywhere. I never knew a patient to vomit any blood —fresh or disorganized—nor any stercoraceous matter. And I have never had but two patients who passed anything from the bowel during the pronounced stages of the disease. These two were the twelve-year-old girl alluded to, who had the critical discharge; and one other, a married woman, aged about forty; in the latter case the discharge occurred on about the seventh day, after repeated injections of one-ounce doses of olive-oil. The dejecta were hardened, dry, dark, tenacious lumps, about the size of pickled olives. These lumps were covered, or glazed, with a whitish mucus, and there was no fluid discharge whatever excepting the olive-oil.

Treatment. — Among the aboriginal tribes here in Central Ohio, and possibly elsewhere, pulverized *charcoal* was greatly relied on. It was usually exhibited suspended in milk. I think all of our early physicians were agreed that there was an urgent necessity for an early evacuation of the bowels. So urgent was this deemed that many gave repeated and heroic doses of calomel and jalap. Croton-oil was occasionally resorted to, but generally with fatal effect. Occasionally a case was treated with unexpected showering or dashing with a bucket of cold water, and it was sometimes effectual in relieving the constipation.

The "Thompsonians" came in with their *lobelia;* but their treatment soon fell into disfavor, as some of their patients were suddenly thrown into a state of collapse. The domestic practice was not infrequently to give repeated small doses of olive-oil, or to rely upon the "expectant plan." The results are said to have compared favorably with, or to have been even better than, any of the heroic plans. Frequently repeated small doses of soluble citrate of magnesia became quite a favorite plan with many, but a belief in the absolute necessity of an early evacuation of the bowels was finally partially surrendered. The limited secretion, or the arrest of secretion, in the alimentary canal, and the finally recognized arrest or suspension of peristalsis, caused the physician of average ability to recognize the inadvisability of heroic measures of any kind, such as had been persisted in at an earlier day. Some only gave their patients slippery elm mucilage and awaited results. Under the milder plans of treatment the death-rate seemed to lessen. Metallic mercury in half-ounce doses was sometimes given, as in mechanical obstruction of the bowels, but without any appreciably good results.

My own plan—and I recommended it in consultation in some cases in 1852, before my graduation—is to give *quinine* and *alcoholic stimulants*, or the stimulants alone. In my earlier practice I did not stick closely to my convictions, as my plan was universally opposed by the profession in my neighborhood; but when my age and experience—together with my success in this plan, and my independence of unwelcome counsel—permitted me to follow my own convictions, I resorted constantly to my earlier plan, and my success with it brought down the death-rate very perceptibly.

Milk-sickness in Central Ohio has become almost a thing of the past; but if I should ever again be called upon to treat it, I should pursue my old plan of alcoholic stimulants, together with quinine, or without it. I should use egg-nog or milk-punch—whichever was least repulsive to the patient—or both; or if no stimulant could be borne on the stomach—as absorption per rectum could scarcely be relied on—I should resort to hypodermatic injections. *William Morrow Beach.*

MILK, SUGAR OF (*Saccharum Lactis*, U. S. Ph., Br. Ph., Ph. G.; *Sucre de Lait*, Codex Med.; Lactose, $C_{12}H_{22}O_{11}H_2O$).

The peculiar sugar, of which milk contains four or five per cent., is easily obtained by evaporating whey and setting it aside to crystallize. The impure product resulting from this process may then be recrystallized and further purified until it becomes white.

Sugar of milk crystallizes in creamy-white, four-sided, rhombic prisms, of a dull surface and hard and brittle texture. It has a faintly sweetish taste, a gritty feel, and is soluble in about seven parts of cold water. Alcohol, chloroform, and ether do not dissolve it. Most of the sugar of milk of commerce is prepared in Switzerland.

This substance has no special physiological action or medicinal value. It is used wholly as a vehicle or diluent for active medicines, and is in this way employed in the "Abstracts" and "Triturations," in "Dover's Powder" (of the last Pharmacopœia), and in the homœopathic triturations and pills.

See also Milk, Dietetic and Therapeutic Uses of.

W. P. Bolles.

MILLDALE MINERAL WELL. *Location and Post-office*, Milldale, Kenton County, Ky.

Access.—From Covington by the Kentucky Central (Chesapeake & Ohio) Railroad.

Analysis (E. S. Wayne).—One pint contains:

	Grains.
Carbonate of magnesia	0.150
Chloride of potassium	0.077
Chloride of sodium	63.657
Chloride of magnesium	1.052
Chloride of calcium	1.408
Sulphate of lime	0.153
Total	66.497
Sulphuretted hydrogen gas	0.78 cub. in.

Therapeutic Properties.—A saline sulphur water.

Milldale is situated in the northern part of Kentucky, about two miles from Covington. The well was bored to obtain water for use in a distillery. *G. B. F.*

MINNEQUA SPRING. *Location and Post-office*, Minnequa, Bradford County, Pa.

Access.—By the Northern Central Railroad of Pennsylvania.

Analysis (C. M. Cresson, M.D.).—One U. S. gallon contains (47° F.):

	Grains.
Calcium	0.994
Magnesium	0.207
Sodium	0.722
Lithium	trace
Aluminium	0.127
Iron	trace
Manganese	0.226
Chlorine	0.140
Silica	0.700
Zinc	0.028
Carbonic acid	2.053
Boracic acid	2.132
Oxygen (with silicates)	0.138
Loss	0.145
Total solid contents in one U. S. gallon	7.612

Amount of sample, 25 U. S. gallons.

Therapeutic Properties.—Another analysis of this water gives a very small proportion of sulphur. It will be observed that the total solid contents is very small, and to this fact is probably due the beneficial effect generally derived from its use. Taken in such mild doses, and its use persevered in, we not only derive the benefit accruing from water as such, but at the same time are more apt to obtain beneficial results from the mineral constituents. It is employed in all conditions resulting from malnutrition.

Minnequa is situated at an altitude of 1,500 feet above

tide-water, in the Towanda Valley, in the midst of a fine farming country, affording pleasant views and drives. The new hotel, "The Minnequa House," built of brick, has accommodations for three hundred guests, and possesses all the modern improvements. *Geo. B. Fowler.*

MISTLETOE. The European Mistletoe, *Viscum album* Linn., is a yellowish-green parasitic shrub with forking stems, leathery, spatulate leaves, inconspicuous, clustered, axillary flowers, and round, waxy, white berries. It grows abundantly upon the apple and other fruit-trees, as well as on the oak, ash, and other trees of the forest, in most parts of Europe. For medical purposes the twigs and leaves are gathered in the winter and dried. That growing on the oak was formerly considered best; a relic of Druidical superstition, probably, as analyses do not show any essential difference between specimens obtained from several kinds of trees. Mistletoe has a mucilaginous, slightly astringent, slowly bitter taste, and a dull, resinous odor when green which is lost on drying. It contains *sugar*, *gum pectin*, etc., a little *tannin*, a little *essential oil*, some *fat*, and a peculiar, very sticky substance, *viscin*. This latter, in an impure state, is a component of the bird-lime formerly used to catch small birds by glueing their feet to branches, on which it was spread to entrap them. Viscin is also contained in a few other plants. Mistletoe was a sacred plant among the ancient Britons, and is referred to in much of the folk-lore of the Old World, but is now practically obsolete as a medicine. It has been thought efficacious in colics, convulsions, epilepsy, etc.

American Mistletoe, *Phoradendron flavescens* Nutt., resembles the preceding in its general appearance and belongs to the same family. Its leaves and branches are also employed to a slight extent in this country, especially in the South and West, as an oxytocic, in place of ergot; sometimes also in inflammatory or congested conditions of the brain and meninges. In composition it appears to resemble the preceding. Dose, from one to three grams (gr. xv. ad xl.). A fluid extract would be a convenient form.

Allied Plants.—There are quite a number of species of mistletoe (*Viscum*), one or two of which at least have been substituted for the typical *V. album*. The order, *Loranthaceæ*, comprises several hundred parasites, mostly tropical, but none of established medicinal value.

Allied Drugs.—Ergot, corn smut, etc., as oxytocics.

W. P. Bolles.

MOGADOR. The town of Mogador lies directly upon the Atlantic coast of Morocco (Lat. 31° 30′ N., Long. 9° 45′ W.), being built upon a low ridge of calcareous sandstone, not more than twenty feet high, which, according to Lombard, constitutes a small peninsula jutting out beyond the general coast line; and according to the writer in the "Encyclopædia Britannica," "is turned almost into an island in certain states of wind and sea." A rocky island lying opposite the town shelters it from all ocean winds except those coming from the southwest.[1] According to the "Encyclopædia Britannica" the intervening harbor or roadstead is sheltered except during the prevalence of west and southwest winds. The population of the town is about fifteen thousand (7,000 Jews, 150 foreigners).[2] The Atlas Mountains approach the town to within a distance of fifteen miles. Of this range it is said[2] that its average height at its western extremity is four or five thousand feet, while at a distance of but sixty miles back from the coast it attains an elevation of ten thousand feet. By this lofty range of mountains Mogador is protected against the desert winds. Dr. Lombard[3] says that "the desert wind or sirocco is never felt there," while Dr. Yeo says that it is scarcely felt, blowing on an average on about two days in each year, and then having much less effect on the thermometer than it has in Madeira. Although the Atlas Mountains "send down streams that cover the land with vegetation,"[1] nevertheless in the immediate neighborhood of Mogador vegetation is extremely scanty and the country is by no means attractive. Says Dr. Yeo:[1] "The low tertiary limestone rock on which it is built is covered up to the city walls with blown sand, driven along the shore before the southwest wind, forming dunes that cover the whole surface; and in most directions one may ride two or three miles before encountering any other vegetation than a few paltry attempts at cultivating vegetables for the table, within little inclosed plots, whose owners are constantly disputing the ground with the intrusive sand." As for the town of Mogador itself, it is remarkable for its cleanliness. "The town," says Dr. Yeo, "is in one respect the most habitable in Morocco, being remarkably clean, and, in that respect, superior to many seaports in Europe. The narrow, but regularly built streets contain houses, mostly of two stories, inclosing a small court-yard, which is entered by a low and narrow doorway from the street. In the Moorish town, inhabited by natives of the lower class, the houses are of one story, and poor in appearance; but the practice of whitewashing within and without once every week makes them look clean, and, no doubt, has much to do with the remarkable immunity of the place from contagious and epidemic diseases." The breaking of the Atlantic waves upon the rocks to the northwest, and north of the city frequently fills the atmosphere with saline particles, and to such an extent that in the Jews' quarter of the city, which lies most exposed to this influence, salt spray may be deposited upon objects of every sort, including the clothing and persons of the inhabitants.[3] It is evident that Mogador has, in marked degree, at least two chief characteristics of a sea-coast station, viz., a sandy soil and a brine-laden atmosphere. Let us see how it stands in respect to equability of temperature. The observations of M. Beaumier, quoted by Dr. Yeo, show a mean annual temperature at Mogador of 66.09° F. This figure was derived from eight years of observation. The mean temperature "for the hottest years" was 68.65° F.; "for the coldest years" it was 65.75° F. The mean annual maximum was only 82.05° F.; the mean annual minimum was 53.00° F. Hence the mean annual range would be less than thirty degrees Fahrenheit. The absolute maximum for the eight years was only 87.08° F.; the absolute minimum was 50.07° F.; so that the extreme range of the thermometer during the period in question was only 37.01° F.

Dr. Yeo mentions, however, that an accurate estimation of the daily range of temperature had been impossible, "as there were no self-recording instruments employed;" and this fact must not be forgotten in estimating the value of the figures given. Such observations as had been made without the aid of self-recording instruments indicated an average nycthemeral range "of about five degrees Fahrenheit, and rarely exceeding eight degrees." The following short table of monthly mean temperatures, which shows between the highest and lowest monthly means of the year a difference of only ten degrees, is also copied from Dr. Yeo's book.[1]

Summer.		Winter.	
June	70.8°	December	61.4°
July	71.1°	January	61.2°
August	71.2°	February	61.5°

The northeast trade-winds prevail at Mogador, and on about two hundred and seventy-one days of the year the direction of the wind is either from the north or the northeast.[1] A glance at the map of Morocco will show that at Mogador these winds are emphatically 'long-shore winds, the trend of the whole coast-line from Mogador to Cape Spartel (a distance of 375 miles), being in a direction from southwest to northeast; hence we can well understand why "the north-northeast winds come saturated with vapor, and charged with minute particles of salt from the breaking of the Atlantic waves on the reefs near the town," as Dr. Yeo says they do; and we may not unreasonably suppose that these winds would be thoroughly impregnated with saline exhalations long before they passed over such coast rocks as lie in the immediate neighborhood of Mogador. The total annual rainfall at Mogador is only ten or twelve inches,[3] and it occurs chiefly, if not almost exclusively, during the colder months of the year. The number of rainy days in winter and spring is 28.[3] Dr. Yeo puts the average number of such

days throughout the year at 45.[1] "From the end of November to the beginning of April," we are told by Dr. Lombard,[3] "there are frequent showers, which occur with westerly and southwesterly winds; they last for three or four days, and then the north wind brings back the sun and the clear sky. A fall of rain is a rare occurrence throughout the rest of the year." There is very little cloudy or foggy weather at Mogador. "Out of 1,000 observations on the state of the sky, the proportions were: clear, 785; clouded, 175; foggy, 40; the latter entry referring to days when a fog or thick haze prevails in the morning, but disappears before mid-day."[1]

So far as climate alone is considered, the figures and statements already adduced would indicate that among coast resorts for invalids Mogador deserves a high rank. The experience of Dr. Thévenin, so far as it goes, bears out this supposition. Dr. Thévenin, during a ten-years' practice at Mogador, "had met but five cases of consumption among his very numerous native patients, and in three of these the disease had been contracted from a distance. He had seen, moreover, several cases among Europeans, who had arrived in an advanced stage of the disease, on whom the influence of the climate had exercised a remarkable curative effect."[1] Dr. Lombard, in alluding to these few favorable results in the case of European visitors, states that their stay at Mogador was a long one. He also tells us that Dr. Thévenin had caused suitable accommodations for foreign invalids to be made at Mogador ("a fait disposer une maison propre à recevoir les malades que l'on envoie sur ces côtes du Maroc").

The reputation of Mogador as a health station is yet to be made. Climatically it promises much; in all other respects it promises little. Dr. Yeo closes his account of the place in these words. "There is a competent resident French physician. The chief drawbacks at present would probably be in respect of the food-supply, certain comforts necessary for invalids, and society. It may be that Mogador is destined to succeed to the renown, as a sanatorium for consumptives, once possessed by the adjacent island of Madeira." *Huntington Richards.*

[1] Climate and Health Resorts. By J. Burney Yeo, M.D.
[2] Encyclopædia Britannica, art. Mogador.
[3] Traité de Climatologie Médicale. By Dr. H. C. Lombard.

MOLASSES (*Theriaca*, Treacle, Br. Ph.). "The uncrystallized residue of the refining of sugar." This well-known liquid is employed in half a dozen formulæ for pills in the British Pharmacopœia to give them suitable consistence. It is also a part of the vehicle of the *Tinctura Chloroformi et Morphinæ* of the same authority—an imitation of the famous proprietary medicine "Chlorodyne." It has the pharmaceutical advantage over syrup that it does not crystallize and become granular as it dries. Physiologically its action is that of a very slight laxative. It is frequently given to infants for that purpose by nurses and mothers. The thick, sweetened syrup of stewed prunes, however, as prepared for the table, is better. *W. P. Bolles.*

MOLITG is a spa in the Département des Pyrénées Orientales, France, lying at an elevation of about 1,450 feet above the sea. It enjoys a rather mild winter climate, and in summer the heat is seldom oppressive. There are from ten to fifteen hot sulphur springs. The following is the analysis of one of these springs. One litre of water contains of

	Grammes.
Sodium sulphide	0.0436
Sodium carbonate	0.0715
Potassium, calcium and magnesium carbonate	0.0044
Silica	0.0411
Sodium and calcium sulphate	0.0124
Sodium chloride	0.0168
Organic matters, etc	0.0103
Total solids	0.2001

The temperature of the different springs varies from 21.8° to 38° C. (71° to 100° F.).

The waters are employed internally and in the form of baths. The baths are very pleasant to take, on account of the softness and a peculiar unctuous character which the water possesses. Chronic catarrhal inflammations of the respiratory passages, skin diseases, especially those accompanied by exudations, ulcers, rheumatism, and uterine disorders, are among the affections for the relief of which Molitg is chiefly frequented. *T. L. S.*

MOLLUSCUM EPITHELIALE, formerly called molluscum contagiosum, is an affection of the skin characterized by the appearance of rounded, semiglobular or wartlike papules or tubercles of a whitish or pinkish color, varying in size from a pin-head to that of a pea. The lesion frequently looks like a drop of white wax upon the skin, or like a pearl button flattened on top, constricted around the base, and with a dark aperture in the centre, from which can sometimes be squeezed a milky fluid.

The lesions usually occur on the face, especially the eyelids, cheeks, and chin They are also met with on the neck, breast, and genitalia.

They may increase in size slowly or rapidly, and usually show no sign of inflammation, though this may exist

FIG. 2241.—Molluscum Epitheliale. (After C. W. Allen.)

at times. They eventually terminate by disintegration and sloughing of the mass. They give rise to no pain, itching, or other inconvenience.

The cause of the affection is unknown. Bateman, who originally described it and gave the designation *M. contagiosum*, arrived at the conclusion of its contagiousness on insufficient evidence, and later observers have preferred qualifying the disease by a term descriptive of its anatomical characteristics. While numerous clinical facts are on record which seem to indicate the spread of M. epitheliale from individual to individual, equally numerous instances have been brought forward to show the impossibility of contagion. Experiments in inoculation have been too few in number and too inconclusive to have much weight.

The diagnosis of M. epitheliale is not difficult. It is sometimes liable to be mistaken for M. fibrosum, but the two may be distinguished by their anatomical characters. In M. epitheliale the opening into the sac can usually be seen as a blackish point at the apex of the tumor. The lesions are superficial and rise above the skin. They are mostly confined to the regions about the face, though

exceptions to this rule occur. The tumors of M. fibrosum do not show the black follicular opening; they are deep and often imbedded in the skin, or even in the subcutaneous tissues. They are found in great numbers all over the body, and are not confined to one or two localities.

From warts, which the tumors of M. epitheliale occasionally resemble, and sometimes are concomitant with, they must be distinguished by a careful comparison of structure.

The pathological anatomy of molluscum epitheliale has formed a frequent subject of investigation within the last few years. It was formerly thought that the process originated in the sebaceous follicles, but the growth is now generally believed to originate in the cells of the rete, and frequently in the rete-cells of the external hair-sheath. The change in growth may commence near the neck or near the root of the hair. After the tumor has existed for a time the hair falls out, and the orifice of the hair-follicle forms the central opening referred to in the description of the lesions. The cells composing the tumor become changed in character and lose their nuclei, and finally the cell becomes entirely changed, except its peripheral parts, and it then forms the so-called molluscum corpuscle. The exact nature of the transformation is not known, but the affection, in all probability, should be classified among the new-growths (Robinson).

Local treatment is alone required in the treatment of molluscum epitheliale. Applications of ointment of white precipitate or of sulphur ointment, well rubbed in, will sometimes remove the tumors. If this fails, they may be opened with a small knife, or scraped away by the curette. The bottom of the cavity should be cauterized with nitrate of silver or some other mild caustic, but severe measures should never be used, because the disease is slight, and tends to disappear spontaneously.

Reference may be made to the treatises of Hyde and Robinson (the latter particularly) for the pathological anatomy of M. epitheliale; also to the paper of G. H. Fox, read before the American Dermatological Association in 1877, and to a recent article of interest, by Dr. Charles W. Allen, in the *Journal of Cutaneous and Venereal Diseases* for August, 1886. Foreign contributions to the subject are noted in an article by H. v. Hebra, in the *Monatshefte f. Prakt. Dermatologie*, v. i., p. 270.

Arthur Van Harlingen.

MOLLUSCUM FIBROSUM. A chronic hypertrophic affection of the skin, characterized, according to the variety of the affection, by a single or a few pendulous tumors, or by numerous sessile or pendulous growths of the cutaneous connective tissue.

The affection has been variously called *molluscum simplex*, *molluscum pendulum*, *molluscum fibrosum* or *areolo-fibrosum*, *molluscum albuminosum*, and *fibroma molluscum*. Of all these designations that of fibroma molluscum appears to be the best, and will be used in the course of this article.

There are two forms in which fibroma molluscum presents itself, one where the surface is covered with a number of small or moderately-sized tumors, the other characterized by the appearance of a single large tumor, or, at most, of two or three tumors. Though it is possible that these two varieties may run into each other, the generalized variety very often showing one or several tumors of large size, and the circumscribed tumor being occasionally accompanied by a number of small lesions, yet it will be convenient to consider them separately.

The generalized variety of fibroma molluscum is that which is usually described under this name, or that of "molluscum fibrosum." It is characterized by the presence of cutaneous tumors, from a dozen or more to thousands in number, sessile or prominent, roundish in outline, soft, indolent, and generally of small size, though occasional exceptions occur. The lesions are found on all parts of the surface, even upon the palms and soles, but are usually most numerous upon the head and trunk, where they are sometimes so closely set as to be confluent; they occur somewhat less frequently upon the limbs, diminishing as the extremities are approached. The genitals are occasionally, though rarely, affected. In some cases, where a post-mortem examination has been made, some of the internal organs have been found to display these tumors, and in several cases they have been observed in numbers upon the nerves.

The lesions vary in size from that of a pin head to a hazel-nut, and are found occasionally as large as a hen's egg, but rarely larger. The smaller ones may be felt in the skin, but rarely rise above the surface, while the larger ones are more prominent, and tend to become pedunculated and pendulous.

Fig. 2345.—Generalized Fibroma Molluscum. (After Wigglesworth.)

The seat of the lesions is in the derma, and they move with it. Their color is that of normal skin, or slightly pinkish; occasionally they are covered with a fine vascular network, giving a violaceous tint. On some lesions, especially those upon the back, the orifice of a dilated sebaceous duct can be seen, from which a plug of sebum (comedo) may be squeezed. The sebaceous glands, how-

ever, are in no way essentially connected with the growth; nor are the hairs, though the latter occasionally fall out, probably from pressure.

The tumors are of variable consistence, but they are always more or less soft and flaccid, excepting in the case of the larger ones, which are occasionally distended and firm, with a smooth, glistening surface, as if the tumor were œdematous. Alongside of such tumors may be seen others, which have a flaccid, empty feeling, like a

Fig. 2346.—Generalized Fibroma Molluscum, with Pendulous Lesions. Back View. (After Keegan.)

scrotum without its testicles, or a raisin deprived of seeds. A curious point is that, although the tumor can be rolled between the fingers, firm pressure reveals a firmer central core of tissue tolerably defined to the touch.

Generalized fibroma molluscum is an indolent disease, and patients rarely come under the notice of the physician, excepting for some intercurrent affection. In the more extensive cases (as many as 3,000 tumors have been counted upon one person) the affection always appears stationary. When, however, the number of lesions is comparatively small, not over fifty or sixty, one or two of them may sometimes be observed to change, increasing in size slowly at first, and later more and more rapidly, until they may in time acquire an enormous size. The period in which this change takes place varies in different cases. It may occur at puberty, or during gestation, if the tumor be seated upon the labia. The growth thus distinguished becomes pendulous, while preserving its rounded form, or takes the form of a dewlap, approaching to the kindred formation known as dermatolysis, pachydermatocele, cutis pendula, etc. (See Dermatolysis.)

Circumscribed fibroma molluscum commonly occurs in the form of one, two, or rarely three, tumors (which in the latter case are situated alongside of one another), of variable, but always considerable, size, which is the greater according to the age of the tumor.

In some cases the dimensions of the tumor may be enormous, as in the case reported in Bell's "Principles of Surgery," where a woman showed an enormous fold of skin springing from the ear, which was greatly elongated, and from the back of the head, covering the neck, the chest, and the abdomen, and falling in voluminous folds like a mass of intestines. The patient, when seated, was obliged to carry the enormous mass in her lap. Valentine Mott has described a similar case.

Fig. 2347.—Generalized Fibroma Molluscum, with Pendulous Lesions. Side view. (After Keegan.)

The localities from which these single tumors spring are the temple, the upper eyelid, the nucha, behind the ear, and at the level of the last cervical vertebra, the chest below the breasts, the hip, and chiefly the labia majora. In one case the growth sprang from the sole of the foot.

The tumors are often flattened, resembling a mantle, and not infrequently a series of capes or folds; at other times they are rounded, elongated, and lobulated. When they have attained a certain size the integument at the base seems to give way, and forms a pedicle of greater or less length, which has given rise to the term "molluscum pendulum."

The skin covering the lesions in this variety of fibroma molluscum is usually normal or slightly pigmented, smooth, or rough and rugous. In regions provided with hairs these are separated from one another by reason of the distention of the skin; a slight depression is sometimes observed at their base. The sebaceous follicles are occasionally somewhat more developed than in the normal condition.

In consistence these large tumors call to mind that of a pendulous mammary gland.

This form of fibroma molluscum, like the other, is very indolent, and it is only the large size of the tumors that renders them so inconvenient and troublesome that surgical relief is in most cases sooner or later demanded.

Occasionally, under the influence of some mechanical irritation, as of constant rubbing, the tumors may become ulcerated or eroded at some point, and sometimes an abundant hæmorrhage supervenes.

It may be mentioned here, also, that degenerative changes of an inflammatory or malignant character sometimes occur in the tumors of fibroma molluscum, particularly of the variety under discussion.

It is often difficult to obtain a history of the appearance and development of these tumors. Occasionally,

Fig. 2348.—Circumscribed Fibroma Molluscum. (After Schultze.)

when first seen, they have been of very small size, and have remained stationary a long time. More frequently they do not date back far, but have originated in some previously existing congenital pigmentary or verrucous nævus. Now and then the tumor is found to have developed from a cicatrix.

The etiology of fibroma molluscum is obscure. It seems in some cases to be connected with neuroma (see below). Hebra has asserted that the disease occurs in persons of stunted mental and physical growth, and this is the experience of many observers, including the writer; but the assertion has been combated by others. The affection appears to occur more commonly among women than among men. It is rare, only 86 cases having been reported to the American Dermatological Association out of 112,775 cases of disease of the skin. The disease appears in some cases to be hereditary.

Sections of the tumors of fibroma molluscum show an areolar structure formed of bands of connective tissue, within which is an abundant network of fine fibres. The areolæ are filled with a yellow fluid, easily forced out by pressure. The origin of the growth appears to be in the connective tissue surrounding the fat-globules, though there is some difference of opinion as to this point.

An important point in connection with the pathology, and perhaps, as it may prove, in connection also with the etiology of fibroma molluscum, is that brought out by von Recklinghausen in his admirable monograph on this subject. Von Recklinghausen concludes that in all cases where multiple soft fibromata have visibly developed, we find at the same time new-growths, similar to those of the skin, developed, chiefly upon the main trunks of the nerves. These new-growths develop in the connective tissue surrounding the fasciculi of nerve-fibres (endoneurium), and form more or less diffused or circumscribed nodules. The nerve-fibres themselves are unaffected, they are never degenerated, and only rarely diminished in size; the neurilemma is only later and secondarily implicated in the new-growth. In the smaller, soft, superficial fibromata of the skin, fine nerve-fibres are sometimes found running through the tumors. Older tumors are not found to contain nerve-fibres. Von Recklinghausen concludes from these facts that fibromata of the skin (fibroma molluscum) are originally neuro-fibromata, the nerves at first being present, and then disappearing as the tumor grows and the connective tissue becomes predominant.

The diagnosis of fibroma molluscum rarely presents any difficulty. The number and wide distribution of the lesions, the unchanged character of the skin covering the tumors, the variety in size and shape of the latter, and the pendulous character of the larger tumors, are all highly characteristic. From M. epitheliale the tumors are to be distinguished by not having any depression or aperture upon their summits. In the rare cases where this exists a comedo can be squeezed out of the opening. They are, moreover, situated beneath the skin, which is normal over them, whereas the tumors of M. epitheliale are in the skin, which is tightly stretched over them. Multiple neuromata are found in connection with fibroma molluscum. The tumors in neuroma are usually painful. The tumors of F. molluscum are distinguished from those of lipoma by the fact that the latter are soft and lobulated in structure. The circumscribed form of M. fibrosum is liable to be confounded with certain other pendulous tumors, and in some cases the diagnosis may be made more difficult on account of the want of precision in our ideas as to the line to be drawn between M. fibrosum, dermatolysis, pachydermatocele, elephantiasis, etc.

The prognosis of F. molluscum is generally favorable. Occasionally, however, degenerative changes may take place in the structure of one or more of the tumors, with a tendency to malignancy.

The only treatment available for the relief of F. molluscum is the surgical removal of such of the tumors as are unsightly or which interfere with the movements of the body. The knife, or the galvanic loop or cautery may be employed.

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Arthur Van Harlingen.

MONSUMMANO is situated in Tuscany, Upper Italy, about midway between Florence and Pisa, at an elevation of 884 feet above the sea. It is frequented because of a remarkable grotto which is filled with warm steam. There are several compartments in the grotto,

the temperature in which varies from 28° to 33° C. (82° to 91° F.). The grotto contains several small lakes of mineral water. According to an analysis made by Tozzetti, each litre of this water contains of

	Grammes.
Calcium carbonate	0.5340
Calcium sulphate	0.4898
Magnesium sulphate	0.4092
Sodium sulphate	0.0332
Sodium chloride	0.2378
Silicic acid, ferrous oxide, and organic matters	0.1000
Total solids	1.8040

The waters are seldom taken internally, and inhalations of the warm vapor of the grotto are the most commonly employed, though sometimes baths are also taken. The troubles for which relief is sought at Monsummano are rheumatism, neuralgia, hepatic and splenic enlargements following malarial fevers, and catarrhal affections of the air-passages. A course of treatment lasts from ten to twenty days. *T. L. S.*

MONT-DORE is a popular spa in the Département du Puy-de-Dôme, France, lying in a wildly romantic valley, at an elevation of 3,400 feet above the level of the sea. The valley is open only to the northeast and southwest, and the climate is very changeable and often raw and disagreeable. There are numerous mineral springs in the place, eight or nine of which are employed for therapeutical purposes. The following is the composition of three of these springs, according to analyses made by M. Jules Lefort. The amounts are expressed in grammes per litre.

	Source César.	Source de la Madeleine.	Source Rigny.
Sodium carbonate	0.5361	0.5362	0.5375
Potassium carbonate	0.0212	0.0309	0.0232
Calcium carbonate	0.3209	0.3423	0.3092
Magnesium carbonate	0.1676	0.1757	0.1628
Ferrous carbonate	0.0258	0.0207	0.0250
Sodium chloride	0.3587	0.3685	0.3599
Sodium sulphate	0.0756	0.0761	0.0751
Silicic acid	0.1552	0.1604	0.1653
Aluminium	0.0083	0.0112	0.0101
Total solids	1.6694	1.7220	1.6681

In addition, there are traces of manganese and lithium, and of iodide, fluoride, and borate of sodium, and further, 0.00096 Gm. of sodium arseniate in each litre. The temperature of the different springs varies from 109° to 113° F. The waters are employed internally, and also in the form of hot baths, douches, steam- and spray-inhalations.

Mont-Dore is frequented to a large extent by clergymen, actors, teachers, and others who are obliged to use the voice a great deal, and suffer from consequent irritation of the vocal organs. The waters are also used for the treatment of chronic pneumonia and bronchitis in the earlier stages, of spasmodic asthma, rheumatism, gout, chronic disorders of the stomach and intestines, especially those associated with pulmonary tuberculosis, chlorosis and the debility of rapidly growing girls, neuralgia, localized muscular atrophies, stiff joints following sprains, uterine affections, and even Pott's disease of the spine.

The accommodations for visitors are good, though the cost of living is rather high. The season lasts from the middle of June to the middle of September. A course of treatment usually extends over from two to three weeks. *T. L. S.*

MONTESANO SPRINGS. *Location*, Jefferson County, Mo.; *Post-office*, Kimmsick, Jefferson County, Mo.

Access.—By St. Louis, Iron Mountain, & Southern Railroad to Montesano.

Therapeutic Properties.—These are saline-sulphur waters of great value, analogous in composition and therapeutic application to the Blue Lick Springs of Kentucky.

They are situated twenty miles below St. Louis, on the bank of the Mississippi. The grounds surrounding the hotel comprise about two hundred acres of lawn and natural forest trees, laid out with winding walks, with a gentle inclination to the river. The hotel is located seventy feet above the river, which it overlooks. Its appointments are first class. The springs are in a ravine in the rear of the hotel. The surrounding country affords interesting excursions, and the river furnishes good fishing. The name is derived from the words Monte Sano, "healthful height."

Analysis (Professors Potter and Riggs).—One gallon contains:

	Montesano.	Casco.	Council.	Alton.	Pearl.	Thorn.
	Grs.	Grs.	Grs.	Grs.	Grs.	Grs.
Chloride of sodium	365.110	368.210	272.150	337.570	362.520	365.520
Sulphide of sodium	0.339	0.432	.....	1.560	.....	.....
Bisulphide of sodium	.....	.....	1.974	.....	1.644	1.736
Hyposulphite of soda	0.747	0.649	trace	trace	trace	.....
Chloride of potassium	16.370	16.990	11.680	13.050	13.870	15.280
Chloride of magnesium	35.910	34.410	30.990	35.490	46.230	47.500
Bromide of magnesium	trace	0.107	0.347	0.147	0.879	0.409
Iodide of magnesium	0.852	.....	trace	.....	0.024	0.112
Chloride of calcium	.....	.....	.....	.....	3.380	7.220
Carbonate of magnesia	14.050	15.500	.....	5.540	.....	.....
Bicarbonate of magnesia	.....	.....	3.770	.....	.....	.....
Sulphate of lime	32.370	33.930	31.910	38.980	38.490	34.560
Carbonate of lime	71.450	69.970	.....	48.100	.....	.....
Bicarbonate of lime	.....	.....	39.720	.....	57.920	62.440
Phosphate of lime	trace	trace	.....	trace	trace	trace
Silica	0.510	0.670	0.770	0.710	1.250	0.84
Iron and alumina	0.870	0.750	0.460	0.540	0.370	0.38
Volatile suspended matter	.....	.....	.....	.....	2.560	.....
Mineral suspended matter	.....	.....	.....	.....	1.80	.....
Total number of grains	538.578	541.618	393.771	481.687	530.937	535.997
Gases.	Cu. in.	Cu. in.	Cu. in.	Cu. in.	Cu. in.	Cu. in.
Carbonic acid	46.43	43.20	34.30	40.03	44.14	43.24
Sulphuretted hydrogen	1.40	1.60	1.43	1.98	1.76	1.59
Specific gravity	1.007	1.006	1.004	1.008	1.009	1.009

G. B. F.

MONTREAL. The accompanying tables, illustrating the climate of the city of Montreal, Canada, are here introduced for convenience of reference. All the data of Table A, with the exception of those standing in column AA, were kindly furnished by Mr. Charles Carpmael, M.A., F.R.A.S., the Superintendent of the Canadian Meteorological Service. The data of Table B and the Montreal figures of Table C are taken from the reports of the Meteorological Service of the Dominion of Canada for the years 1881 and 1882. For these reports, for obtaining for me the filling-out of the blank form of Table A, and for much other valuable information respecting the climate of British America, I am indebted to the great kindness of the Hon. H. Beaumont Small, of Ottawa. Mr. Small's painstaking efforts to provide me with climatological data from the various colonies of Great Britain demand acknowledgment in this place, over and above that given by the editor of the Handbook in his preface to vol. i.

The period of observations for the data of Table A, save only in the case of the figures in column B, is rather short. Hence the reader who attempts to make use of this table according to the method described at length in the article on Climate (vol. ii., pp. 189–191) must be cautioned to bear this fact in mind. I desire also to call the reader's attention to the standards adopted in column G and in column H of this Montreal chart, standards which differ materially from those adopted in the U. S. Signal Service charts obtained from Washington. In column L the term "fair" is also used in a special sense, signifying, in the case of Montreal, and also in the charts from Winnipeg, Toronto, and Halifax (see article Nova Scotia), days on which neither rain nor snow fell. Finally, in these four charts the averages for the four quarters of the year are given in place of the seasonal averages standing in the Washington charts.

The data of Table B, so far as they go, will help to a better knowledge of the Montreal climate. The nature

TABLE A.

Climate of Montreal, Canada.—Latitude 45° 31′. *Longitude* 73° 33′.—*Period of Observations, January*, 1883, *to December*, 1883.—*Elevation of Place of Observation above the Sea-level*, 187 *feet.*—*Name of Observer, Mc Gill College Observatory.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Mean temperature in 1883, deduced from column A.	Mean temperature for period of observation, 1875–1883.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was 32° and below.	Greatest number of days in any single month on which the temperature was 62° and upward.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January	8.15	10.56	7.76	7.15	22.44	5.67	16.89	1.97	39.0	−12.3	21.0	−20.4	31	0
February	9.97	17.62	13.19	13.59	26.62	9.02	21.71	4.72	44.1	3.0	23.5	−12.1	28	0
March	13.07	21.38	16.44	16.96	31.67	16.68	26.07	6.42	43.0	4.1	29.5	−9.8	31	0
April	32.97	41.82	35.52	36.77	48.10	35.57	44.38	29.56	62.8	26.4	44.6	11.1	18	1
May	47.33	57.08	49.05	51.15	58.60	49.68	59.66	42.92	81.5	41.6	56.9	32.8	0	10
June	62.66	72.53	62.90	66.03	67.48	61.04	74.83	57.97	84.0	64.2	67.3	46.0	0	30
July	64.46	73.19	64.29	67.31	72.60	67.33	75.93	59.01	82.8	66.9	69.5	47.8	0	31
August	62.59	72.97	64.19	66.58	70.09	65.21	74.90	58.25	85.8	65.3	65.2	45.5	0	31
September	51.96	62.96	54.08	56.33	64.08	55.20	65.25	47.86	78.9	48.0	62.4	35.8	0	19
October	40.45	48.10	42.03	43.52	54.00	40.88	50.52	37.10	68.8	39.2	52.5	24.3	8	3
November	32.23	37.33	32.43	33.99	35.93	25.12	40.93	27.94	66.9	14.3	43.6	4.9	15	1
December	12.94	18.09	14.99	15.34	28.47	12.71	24.43	10.41	48.1	−9.1	36.5	19.4	30	0
2d quarter	.....	.....	.....	.....	55.72	49.34	.....	.....	.....	.....	.....	.....	.....	.....
3d quarter	.....	.....	.....	.....	68.01	63.90	.....	.....	.....	.....	.....	.....	.....	.....
4th quarter	.....	.....	.....	.....	36.10	27.60	.....	.....	.....	.....	.....	.....	.....	.....
1st quarter	.....	.....	.....	.....	22.30	12.20	.....	.....	.....	.....	.....	.....	.....	.....
Year	.....	.....	.....	39.56	45.28	38.70	.....	.....	.....	.....	.....	.....	.....	.....

	J	K	L	M	N	O
	Range of temperature for period.	Mean relative humidity.	Number of fair days.	Rainfall in inches.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
					From	
January	59.1	83	14	0.34	S.W.	11.63
February	56.2	78	10	0.51	W.	12.61
March	52.8	73	16	0.01	W.S.W.	12.72
April	51.7	64	15	0.84	W.	11.18
May	48.7	71	9	6.94	W.N.W.	12.02
June	38.0	72	11	3.45	S.W.	9.82
July	35.0	72	13	4.72	W.S.W.	7.91
August	40.3	70	18	1.60	S.W.	9.45
September	43.1	73	15	3.57	W.S.W.	8.34
October	44.5	74	17	2.49	N.W.	8.53
November	62.0	76	9	2.05	S.W.	11.90
December	67.5	83	11	1.03	S.W.	12.69
2d quarter	72.9	69	35	11.23		11.01
3d quarter	50.0	72	46	9.89		8.57
4th quarter	88.2	78	37	5.57		11.04
1st quarter	64.5	78	40	0.89		12.32
Year	106.2	76	158	27.58	W.S.W.	10.73

of these data is sufficiently indicated by the headings of the columns.

Table C illustrates in some measure the points of contrast between the climate of Montreal and that of New York City.

It is evident that the abundance and frequency of the snowfall at Montreal must save that city from the winter dust, which is so annoying and so detrimental to persons suffering from disease of the respiratory tract who are obliged to pass the winter in New York City. The low temperatures of the months of December, January, February, and March, must also of necessity save the streets of Montreal during the coldest part of the winter from frequently occurring visitations of slush; whereas in New York it is a rare thing to have the snow lie in the streets, unmelted, for many days together, even in the dead of winter. On the other hand, the spring melting must be a far more formidable thing in Montreal than it is at New York. Other points of climatic contrast will appear upon instituting a comparison between the New York chart (vol. ii., p. 188) and the Montreal tables given in this place. Despite the inequality existing between the

TABLE B.

	Average mean temperature for a series of years.	Mean temperature.		Absolute maximum temperature.		Absolute minimum temperature.		Rainfall in inches.		Snowfall in inches.		Number of days on which rain fell.		Number of days on which snow fell.		Percentage of cloud.		Percentage of possible sunshine actually enjoyed.	Monthly range of temperature.	Mean daily range of temperature.	Greatest daily range of temperature.	Mean velocity of wind.	Maximum velocity of wind.	Number of fogs.
		1881	1882	1881	1882	1881	1882	1881	1882	1881	1882	1881	1882	1881	1882	1881	1882	1882	1882	1882	1882	1882	1882	1882
January	13.00	10.6	12.2	34.9	42.4	−13.6	−26.0	R	1.18	26.5	28.2	1	4	18	20	58	59	34	68.4	17.68	36.1	14.15	49.0	3
February	17.67	17.6	21.0	44.0	46.2	−16.4	−8.5	2.04	0.58	7.3	23.2	5	4	11	13	62	47	44	54.7	15.57	35.0	13.17	34.0	1
March	25.61	30.1	25.0	46.0	47.0	9.5	1.4	0.24	2.46	391	15.3	8	8	21	15	75	50	53	45.6	15.28	28.8	12.35	33.0	3
April	35.70	39.0	35.6	74.0	57.2	8.3	13.1	0.44	1.58	0.4	3.2	7	11	8	5	45	64	47	44.1	11.07	25.5	11.88	35.0	0
May	54.75	57.7	49.7	86.1	67.5	31.5	27.1	3.25	1.50	....	0.5	21	15	..	1	60	57	48	40.4	18.02	33.0	0.11	10.31	0
June	64.21	61.0	62.7	81.8	86.7	38.0	43.9	1.39	4.74	....	....	12	20	..	..	61	51	60	42.8	17.21	37.5	10.55	28.0	0
July	69.19	69.2	67.6	93.9	84.9	53.7	50.8	3.31	6.04	....	....	18	17	..	..	58	53	63	34.1	15.21	32.0	10.15	24.0	0
August	68.32	69.4	68.3	90.1	91.0	52.2	48.0	2.08	2.52	....	....	10	11	..	..	57	47	68	43.0	17.72	35.0	7.62	18.0	0
September	59.49	64.1	58.2	87.0	79.1	42.0	40.6	1.93	3.63	....	....	11	12	..	..	61	58	53	38.5	14.79	29.5	8.31	26.0	2
October	46.58	45.8	49.1	74.0	74.7	28.0	30.5	3.80	1.34	0.1	...	19	14	5	..	65	50	57	44.2	15.09	34.1	10.02	27.0	4
November	31.63	32.7	31.4	63.2	60.6	−5.5	14.3	1.09	1.39	11.8	1.0	14	14	13	5	74	65	41	46.3	11.24	24.8	9.30	27.0	6
December	19.46	18.5	17.7	44.1	37.1	−1.0	−5.3	3.25	0.01	4.4	39.8	12	3	12	24	73	79	..	62.4	12.54	30.2	11.04	36.0	1
Year	42.51	43.39	41.58	93.9	91.0	−16.4	−26.0	22.82	27.00	89.6	111.2	138	133	88	83	62	57	.	117.0	15.35	36.1	10.83	49.0	20
								31.78*	38.12*			226†	216†											

* Combined rain and melted snow. † Total number of rainy and of snowy days.

TABLE C.

	Average mean temperature.		Rainfall, 1882.		Snowfall, 1882.		Number of days on which rain fell, 1882.		Number of days on which snow fell, 1882.		Percentage of possible sunshine actually enjoyed. 1882.	
	Montreal*	New York†	Montreal	New York‡	Montreal	New York‡	Montreal	New York‡	Montreal	New York‡	Montreal	New York‡
January...	13.00	30.1	1.18	2.12	28.2	17.50	4	11	20	7	34.0	43.0
February..	17.67	31.3	0.58	2.58	23.2	0.85	4	8	13	3	44.0	62.0
March.....	25.64	36.8	2.46	1.90	15.3	0.63	8	9	15	3	53.0	56.0
April.....	37.79	46.9	1.58	1.51	3.2	0.13	11	10	5	1	47.0	56.0
May.....	54.75	59.0	1.50	4.20	0.5	0.0	15	13	1	0	48.0	56.0
June.....	64.24	68.6	4.74	2.52	0.0	0.0	20	9	0	0	60.0	69.0
July.....	69.49	73.7	6.04	3.21	0.0	0.0	17	6	0	0	63.0	71.0
August....	68.32	72.2	2.52	1.14	0.0	0.0	11	6	0	0	68.0	65.0
September	59.49	65.3	3.63	16.85§	0.0	0.0	12	15	0	0	53.0	51.0
October....	46.58	55.5	1.34	1.51	0.0	0.0	14	11	0	0	57.0	52.0
November.	31.63	42.1	1.39	0.21	1.0	1.03	14	2	5	5	41.0	56.0
December.	19.46	32.9	0.04	1.95	39.8	0.0	3	8	24	0	....	55.0
Year.....	42.51	51.2	27.00	39.70	111.2	20.14	133	108	83	19	....	58.7

* Deduced from observations made at three-hour intervals. Period of observations uncertain.
† Deduced from observations made at 7 A.M., 3 P.M., and 11 P.M. Period of observations, thirteen years.
‡ Data from New York State Meteorological Observatory, in Central Park.
§ Exceptionally heavy rainfall. See New York Chart on page 188 of vol. ii. of HANDBOOK.

periods of observation in the case of the two places, the writer hopes that a fairly just and a tolerably accurate conclusion can be reached by such a comparison of data as has just been indicated. A similar comparison may of course be made between the data of Table A and those to be found in the Signal Service charts of such health-stations as Los Angeles, Aiken, Thomasville, Jacksonville, etc., and will be serviceable to readers of this HANDBOOK residing in, or familiar with the climate of, Montreal when studying the health-stations of the United States. *Huntington Richards.*

MONTREUX. The village of Montreux, in the Canton de Vaud, Switzerland, lies at the northeast corner of the Lake of Geneva (Lat. 46° 25′ 59″ N., Long. 6° 55′ E.), directly opposite the opening of the Rhone Valley. Beside Montreux proper some twenty other villages and hamlets, lying close together at this point, are included in the district, or parish, bearing the same name; and it is all these places taken collectively which constitute the health-station of Montreux. Of the other villages comprised within the district, Les Bassets, Clarens, Vernex, Torritet, and Chillon are perhaps those most widely known. Glion, one thousand feet above Montreux, and Les Avants, about two thousand feet above Montreux, are also well-known health-stations. The elevation of Montreux itself above sea-level is twelve hundred and twenty feet. The chief climatic characteristics of this district are its immunity from cold winds and the prevailing stillness of its atmosphere, both of which are due to the very exceptional degree of shelter afforded by the mountains which stand back of the district to the north and east. Montreux itself is the most sheltered of all the group of contiguous villages. "The indentation of the lake, which is here called the Bay of Montreux, is protected by the mountains around from the north and east winds, and in some degree from the northwest wind, so that it is said to be, with the exception of Bex, the most sheltered place in Switzerland. It is also the hottest of all the Swiss stations north of the Alps except Sion, but that applies only to the summer and spring, as Montreux is warmer than Sion in autumn and winter. The 'bise'—the cold northeast wind—is not nearly so much felt at Montreux as at Geneva and Morges; and it has been noticed, during the prevalence of a 'bise,' that it has been intensely cold at Geneva (temperature 14.3 degrees Fahrenheit) and at Morges (temperature 18 degrees Fahrenheit), while at Montreux (temperature 23.6 degrees Fahrenheit) the air has been almost calm and not disagreeably cold. There are also less variations of temperature at Montreux—a smaller range between the maxima and minima" (Dr. J. Burney Yeo, "Climate and Health-resorts"). To the "föhn" wind blowing up from the south, down the Rhone Valley, Montreux is much exposed. To this singular wind, and to its depressing effect upon invalids, reference has been made already in the article on Davos (vol. ii., p. 361). Dr. Yeo tells us that at Montreux "the air is very calm and still, the number of calm days reaching eighty-five to ninety per cent., whereas at Morges it only reaches thirty-three per cent.; and it has been noticed that the lake is often calm from Vevey to Villeneuve when it is agitated in the rest of its extent. But when the hot wind blows from the south, the *föhn*, here called the *vaudaire*, . . . makes the bay of Montreux very rough." The winter temperature of Montreux is moderately cold. Dr. Kisch, in Eulenberg's "Reäl-Encyclopädie," gives the following figures for the mean temperature of each of the seven months from October to April: October, 50.9° F.; November, 41.2° F.; December, 36.5° F.; January, 33.4° F.; February, 39° F.; March, 41° F.; April, 50.7° F. Reference to the New York City chart (art. Climate, vol. ii., p. 188) shows that these figures are some four or five degrees higher than those of corresponding months at that city, except in the case of the month of October, which is nearly five degrees warmer at New York than it is at Montreux, and in the case of November, which is about one degree warmer at New York than at Montreux. The mean winter temperature of Montreux is 36.32° F., according to Dr. Kisch, and 36.5° F. according to Dr. Yeo; at New York the winter mean is 31.4° F. The mean temperature at the hours of 7 A.M., 1 P.M., and 7 P.M. in each of the four seasons, and in each of the seven colder months of the year; the mean temperature of the winter, of the spring, and of the year; and the mean and absolute maximum and minimum temperatures, all of them derived from seven years of observation, are given by Dr. Yeo, and are quoted below.

	7 A.M.	1 P.M.	7 P.M.
	Degrees.	Degrees.	Degrees.
October	47.0	56.6	49.0
November	38.7	47.5	41.0
December	34.3	41.5	35.9
January	31.8	39.7	33.9
February	35.0	44.0	38.1
March	37.0	45.2	39.7
April	46.0	57.6	50.4
Spring: March to May	46.6	56.4	49.4
Summer: June to August	61.7	72.7	63.7
Autumn: September to November	47.3	57.4	49.8
Winter: December to February	33.8	41.7	35.9

	Degrees.
Mean annual temperature	51.0
" winter "	36.5
" spring "	50.8
" maximum " (July)	77.0
" minimum " (January)	35.2
Absolute maximum temperature (July 8, 1870)	89.0
" minimum " (February 12, 1865)	11.4

Dr. Kisch states that the nycthemeral range of temperature at Montreux varies from 12° C. to 16° C. (21.6° F. to 28.8° F.); but this statement is very surprising in view of the figures just quoted from Dr. Yeo. The mean annual rainfall is 50 inches; the number of rainy days in winter and spring is 21, the total number of such days throughout the year being 60 (Dr. Yeo). Dr. Kisch puts the annual number of rainy days at 70, and tells us that the mean relative humidity is 74.7 per cent.

Snow falls, of course, at Montreux, but how frequently and to what depth I do not know. In Flechsig's Bäder Lexikon we are told that the snow melts rapidly, a thing which might readily have been inferred from the sheltered position of Montreux, freely exposed only to southerly and southwesterly winds. We are also told by the same authority that, despite the very considerable degree of winter cold and the occurrence of snow, there are, almost every winter, even in December and January, certain days during the warmer part of which an invalid can safely sit out in the open air for several hours.

As a rule, fogs occur but rarely during the winter season; yet they were frequent in the winter of 1875–76.[1] What remains to be said respecting the climate cannot be better told than by direct quotation from Dr. Yeo's admirable work on "Climate and Health-Resorts."

"In an average winter a good deal of cold weather must be expected at Montreux, as its mean winter and spring temperature is some five degrees Fahrenheit lower than that of Ventnor, and four degrees Fahrenheit lower than that of Torquay; but in favorable seasons, on the other hand, a good many bright, clear, sunny days may be expected, and comparatively few rainy ones. In November there are often a good many cold, damp, and disagreeable days.

"In spring the weather is often very variable. There are, perhaps, some very fine days, and then a sudden and unexpected return of cold, with rain or snow; so that invalids need to take great precautions at this season. Patients often ascend to Glion at this period of the year. Few people spend the summer at Montreux on account of the heat, but the autumn is a fine season up to the middle of October, when storms of rain frequently set in and there is occasionally a passing snowfall. It is in the autumn that the grape-cure is in active progress at Montreux.

"It is an advantage at Montreux to have two mountain stations of different elevations, such as Glion and Les Avants, so readily accessible; for it does happen during some seasons that there is much more sunshine to be found at the higher resorts than at the lower one, and this fact is easily ascertainable.*

"The winter and spring climate of Montreux, it will be seen, is by no means a perfect one; it has, however, been pointed out, as a kind of compensation, that the hotels and *pensions*, which abound here, are very comfortable, and that if the weather out of doors is bad, the invalid can find good shelter and protection indoors."

With reference to this last statement of Dr. Yeo's, it is perhaps well to remark that Dr. Kisch [2] pronounces Montreux to be very inferior to Meran, in respect to out-of-door accommodations for invalids, such as parks (Anlagen), roads, and resting-places (Ruheplätzen); he says that there is a lack of variety in the food provided, and that it is not especially nourishing (nicht besonders kräftig), and that those who stay long at Montreux, even in the autumn, are apt to suffer from *ennui*. Nevertheless, despite its climatic inferiority in many respects to many more southerly health-resorts, the general excellence of its hotels and *pensions*, the moderate cost of living, and the facilities for good schooling which there exist, still combine to render Montreux an attractive place of winter residence to many families; and to these attractions must be added the surpassing beauty of the scenery. The view of the Savoy Alps, which rise like a wall on the opposite side of the lake, and of the grand, snow-crowned peaks which hem in the Rhone Valley, must be seen to be adequately appreciated.

Climatotherapy.—The climate of Montreux is said to be unsuited to cases of advanced pulmonary phthisis, accompanied by marked febrile symptoms or by free secretion, and also to nervous patients having a tendency to depression of spirits.[3] Dr. Yeo tells us that prolonged residence at Montreux is said to be serviceable in "cases of simple chronic laryngitis, of chronic laryngo-pharyngitis, of granular pharynx;" and that "all these chronic throat affections have a good chance of cure at Montreux, especially if they are, at the same time, submitted to local treatment by inhalation," etc. He includes in his list of cases, said to be benefited by prolonged sojourn at Montreux, "cases of recurrent bronchial catarrh or tendency to catarrh, as well as cases of chronic bronchial catarrh when not too inveterate or severe; persons with hereditary predisposition to consumption, and cases of chronic phthisis and early phthisis when the general health and strength are otherwise good and there is an absence of fever; cases of chronic pleurisy with suspicion of the commencement of phthisis, as well as cases of chronic empyema healing slowly; cases of cardiac valvular disease of rheumatic origin, to ward off bronchial catarrh and fresh rheumatic attacks, also cardiac neurosis, especially if induced by excess of tobacco-smoking."

For information concerning the "grape-cure," which is practised during the autumn at Montreux, and at certain other resorts in Switzerland, and elsewhere in Europe, the reader is referred to Dr. Irving C. Rosse's article, entitled Grape-cure, in vol. iii. of this Handbook, and to the article on Meran, in vol. iv.

Huntington Richards.

[1] Climate and Health Resorts, by Dr. J. Burney Yeo.
[2] Article on Montreux, in Eulenberg's Real-Encyclopädie, vol. ix.
[3] Bäder-Lexikon, by Dr. Robert Flechsig, art. Montreux.

MONTVALE SPRINGS. *Location and Post-office*, Montvale, Blount County, Tenn.

Access.—By Knoxville & Augusta Railroad to Marysville, thence by carriage to the springs, nine miles.

Analysis.—One pint contains (60° F.):

	Prof. J. B. Mitchell. Grains.	I. R. Chilton, M.D. Grains.
Carbonate of iron	0.300	.....
Carbonate of lime	1.657	.....
Chloride of sodium	0.245	.....
Chloride of magnesium	.....	0.012
Chloride of calcium	.....	0.018
Sulphate of soda	0.564	1.102
Sulphate of magnesia	1.500	2.134
Sulphate of lime	9.276	10.243
Oxide of iron	.....	0.149
Alumina	0.062	.....
Silica	.....	trace
Organic matter	.....	0.005
Total	13.604	13.663

Therapeutic Properties.—The characteristic constituents of this water are lime and iron. As tonic and alterative agents they enjoy a fixed reputation as being of great service.

They are situated at the base of the Chilhowee range, in the eastern part of Tennessee. The scenery is grand and picturesque, affording fine drives over good roads. Montvale Springs Hotel, known as the "house of seven gables," furnishes ample and good accommodation for four hundred guests. There is a black sulphur spring within three miles of the hotel. *G. B. F.*

MOONSEED, CANADIAN (*Menispermum*, U. S. Ph.; "Texas sarsaparilla," "Yellow parilla"), *Menispermum canadense* Linn., is a woody climber, with excentrically peltate, angled or lobed, alternate leaves, and axillary panicles of white, dicœcious flowers; sepals, four to eight; petals, six to eight; stamens, twelve to twenty; pistils, two to four. Fruit a globular black drupe, with crescentic stone and embryo.

Moonseed arises from a long, slender rhizome, which, with its adhering rootlets, is the officinal portion. It is dried in flexible, tough pieces, a metre or so in length, and about five millimetres in thickness, with a finely shrivelled brown bark and bright yellow section. Odor slight, taste bitter. It grows in most parts of North America, and was introduced into medical use, thirty or forty years ago, as a substitute for sarsaparilla in "scrofulous affections," etc. There is no evidence to show that it is anything but an inferior bitter tonic. Its compost

* The elevation above sea level of Les Avants is almost precisely the same as that of Chateau d'Oex, a place lying about ten miles northeast of Montreux. The sun *temperatures* of the latter place, compared with those of New York City, have already been given in the course of the article entitled Davos (see vol. ii., p. 358). Respecting the sun temperatures at Montreux I possess no data; neither have I data showing the relative prevalence of sunshiny weather at Montreux, or at Chateau d'Oex, and at New York City. *H. R.*

tion—*berberine* and a white, crystalline, bitter alkaloid soluble in water—recalls its near botanical relatives, COLUMBO and PAREIRA. *W. P. Bolles.*

MORPHŒA. An affection of the skin characterized by the appearance of one or more patches of various size, roundish or ovoid in shape, on a level with the surrounding skin, smooth or slightly scaly, and giving a sensation of peculiar firmness to the touch.

The patches show two zones of coloration. The central part is usually of a grayish or yellowish-white color; it is separated from the healthy skin by a lilac-colored ring showing enlarged capillaries.

These patches are found on all parts of the body, but are most commonly met with upon the neck, chest, abdomen, and limbs. They give rise to no pain, nor, in fact, any sensation, excepting occasionally some slight itching.

Morphœa is now regarded by most writers as a trophoneurosis, and one of the earlier stages of scleroderma. Pautry, however ("Thèse de Paris," 1883), inspired by Vidal, considers it a substantive and independent affection. The question will be discussed in the article on Scleroderma. *Arthur Van Harlingen.*

MORTALITY. The study of the law of mortality, or the relation of the number of persons *dying* to the number *living*, under the various conditions subject to which human life is found, is at the foundation of undertakings of immeasurable importance to the business of men and the interests of humanity. The comparative mortality of different cities or countries, for instance, is a starting-point from which to investigate the circumstances and surroundings most favorable to longevity; and a knowledge of the chances of life at each age, based on repeated observations, allows vast financial transactions, in life insurance and kindred enterprises, to be carried on with safety and with equity.

The rate of mortality of a given city or country is commonly measured by the number who die in one year out of one thousand persons living; thus, if 271 deaths occur in one year in a population of 14,000, the death-rate would be said to be $(\frac{271}{14000}) = 19.4$ per thousand. It is also sometimes described by the number of persons living to each one dying, or the number out of which one dies, which in the example given would be $(\frac{14000}{271}) = 52$. It is to be noticed that by the former method the higher the given number (of deaths per thousand) the greater is the mortality; while by the second method the higher the given number (of living out of whom one person dies) the less is the mortality. In making comparisons between the death-rates of different places, the number of living should be taken for the middle of the year during which the deaths occur, or at a mean between the population at the beginning and that at the end of the year; for it is quite evident that two places might have the same population at a given date, and yet, by reason of greater increase in one than in the other, have a decidedly unequal average population for the year following. It is to be noted, however, that this mean basis is not always the one used; in the United States Census of 1880, for instance, the population was taken at the *end* of the census year, and ratios were based upon the numbers so found.

In discussing mortality in its relation to life insurance the methods are somewhat different, as will be explained further on.

There is perhaps no field of scientific observation where one has greater need to beware of false conclusions, even from data that, so far as they go, are correct, than in computing and comparing rates of mortality. For instance, it is stated that Dr. Price, in constructing the Northampton tables, was seriously misled, as to the number of births and the increase of the total population, by the fact that there existed in the town of Northampton "great numbers of Baptists, who repudiated infant baptism;" and the records of christenings which he used, consequently, indicated a number of births that was materially below the true one. So also popular places of resort for consumptives, such as Minnesota and Southern California, would doubtless show a number of deaths from lung-disease entirely out of proportion to the number due to the natural influences of the locality, and might have the total death-rate materially affected as a result. Again, a city whose inhabitants were accustomed, in large numbers, to leave it for a time at certain seasons of the year, would, other things being equal, show a smaller number of deaths to the same total population than one where this was not the case. To give still another example of the necessity of care in deciding what causes have produced certain known results, the Forty-fourth Registration Report of Massachusetts shows that the average age of persons dying in 1885 was, in Barnstable County, 51.95 years, and in Berkshire County, 35.23 years. The inference might be drawn that the former was a vastly healthier place than the latter; but the census shows that in Barnstable County the population has diminished fourteen per cent. in twenty years, while in Berkshire County it has increased thirty per cent., so that *a* cause, if not *the* cause, of the difference in age of decedents is that the young people of Barnstable County have been migrating from it.

No accurate information is obtainable as to the death-rate throughout the United States. Massachusetts, New Jersey, and the District of Columbia, and some nineteen cities outside of their boundaries, have systematic reports of the deaths that take place in their limits that are doubtless nearly correct; but in a great part of the country there is a sad lack of appreciation of the value of records of this kind, and in the more thinly settled parts of the country the difficulties in the way of keeping an accurate and systematic registry would be very considerable. In the last four censuses of the United States, viz., those of 1850, 1860, 1870, and 1880, attempts have been made to gather some information as to mortality, but the effort to gain from the memories of living persons a full report of all the deaths that had taken place during a stated term of twelve months (ending in many cases some months before the time at which the inquiries were answered) has fallen so far short of getting at the whole truth, that it is estimated that not more than some sixty to seventy per cent. of the actual deaths were reported. In taking the tenth, or 1880, census, special efforts were made to get full death reports, by inquiries of physicians in addition to the questions asked by the regular enumerators, and by still other corrections for certain localities; and the result showed a death-rate of 15.1 per thousand (against 12.8 in 1870, and 12.5 in 1860); while the writer of the census report believes the true rate to be about 18 per thousand.

In European countries, on the other hand, full records are generally preserved. In England, Bills of Mortality were first ordered to be kept in 1538, and from the end of the year 1603 to the present time the London bills of mortality have been continuous. The object for which they were at first instituted was to inform and quiet the public mind as to the extent of the ravages of the plague.

In reports of the mortality of a city or State, it is usual to show the number dying at each age, or five-year group of ages, and to classify the deaths by cause, by sex, and in other ways. A general classification of causes that is adopted by eminent authorities is into Zymotic, Constitutional, Local, Developmental, and Violent, with subdivisions under each head. Still-births are not generally counted as deaths by State and city officials in computing death-rates.

In the general mortality statistics of the tenth census it was intended to have still-births included among the deaths, and they were so included, except for the State of New Jersey, and the cities of Richmond, Washington, and Wilmington. In the life-table calculations in the latter part of the census report, still-births are omitted. "The total number of children reported as still-born was 24,876, being 3,287 out of each 100,000 deaths from all causes."

The following table, from the report of the tenth cen-

sus, shows, for each of thirty-one "registration" cities, the number of deaths during the year ending June 1, 1880, to each thousand of population living at the end of that time. It will be noticed that the death-rates are given for the whole population, and also for the males and females separately, and with classification, in the case of six Southern cities, by color as well as by sex.

TABLE No. I.

CITIES.	Total.	Male.	Female.
Cambridge	17.46	17.66	17.28
Camden	18.17	18.67	17.71
Nashville	18.22	19.36	17.15
Worcester	18.40	19.11	17.70
Lynn	18.65	19.24	18.12
Newark	18.68	21.02	16.49
Lowell	19.20	19.29	19.12
St. Louis	20.07	21.81	18.23
Cleveland	20.14	20.91	19.36
Jersey City	20.27	22.07	18.50
Philadelphia	20.40	21.91	19.01
Milwaukee	20.49	22.04	18.96
San Francisco	20.50	23.17	17.02
Chicago	20.77	21.77	19.72
Lawrence	20.99	22.26	19.93
Pittsburgh	21.05	21.51	20.59
Cincinnati	21.35	23.81	18.97
Wilmington	21.42	21.78	21.07
Providence	21.54	22.61	20.57
Paterson	22.12	22.45	21.81
Brooklyn	22.24	23.64	20.94
Indianapolis	22.27	23.35	21.23
Boston	22.32	23.53	21.22
Louisville { White	20.04	21.82	18.36
Louisville { Colored	34.76	39.86	30.73
Louisville Both together	22.53	....	....
Washington { White	17.80	18.97	16.73
Washington { Colored	35.45	39.19	32.60
Washington Both together	23.61	....	....
Fall River	24.42	24.86	24.03
Richmond { White	19.12	19.50	18.76
Richmond { Colored	31.97	36.51	28.48
Richmond Both together	24.75	....	....
Baltimore { White	22.71	24.40	21.13
Baltimore { Colored	37.61	44.05	32.81
Baltimore Both together	25.12	....	....
New York	25.37	27.26	23.55
New Orleans { White	22.41	26.93	18.28
New Orleans { Colored	35.61	42.30	30.42
New Orleans Both together	25.94	....	....
Charleston { White	23.78	26.22	21.65
Charleston { Colored	45.00	48.55	42.22
Charleston Both together	35.37	....	....
Total (thirty-one cities)	22.28	23.92	20.72

As an illustration of the variation in death-rates from year to year, the rates for two cities are here given, for six years, from figures by the local authorities:

DEATH-RATE PER 1,000.

	1880.	1881.	1882.	1883.	1884.	1885.
New York	26.47	31.08	29.64	25.81	25.82	25.53
Providence	19.83	19.56	19.60	19.89	19.00	18.32

For two States the figures are as follows, viz.:

DEATH-RATE PER 1,000.

	1881.	1882.	1883.	1884.	1885.
Massachusetts	20.09	19.91	20.07	19.33	19.61
New Jersey (year ending June 30th)	18.39	22.90	20.60	19.20	18.63

For several foreign cities the death-rates in 1880 were as below:

London	22.14	Berlin	29.24
Liverpool	27.22	Bremen	20.89
Paris	26.18	Vienna	28.17
Madrid	40.18	Glasgow	22.53
Odessa	37.28	Edinburgh	21.50
Havana	40.64	Rio de Janeiro	33.22
Amsterdam	26.96	Stockholm	28.79
Dublin	35.94	Melbourne and suburbs	19.18

And the showing of certain foreign countries is as follows:

	1880.	1881.	1882.
England and Wales	20.5	18.9	19.6
England (rural districts)	18.5	....	....
France	22.8	22.0	22.2
Austria	29.6	30.6	30.8
Prussia	25.5	24.9	25.2
Sweden	18.1	17.7	17.4
Italy	30.5	27.6	27.5
Switzerland	21.9	22.4	21.9

France (average, 1869-1877)	22.6
Spain (average, 1861-1876)	29.7

For what may be called the mathematical and financial purposes of a mortality table, that is, for the construction of a safe foundation for the vast system of life insurance and annuities, and the settlement of all kinds of property interests whose values are dependent on the duration of human life, the collection and arrangement of facts differ somewhat from those already alluded to, where information of the progress and sanitary status of a community was what was mainly sought. The exact mortality at each age is, in the monetary problem, of more importance than an analysis of the causes of death; and for many purposes the rate of mortality in childhood is not an essential element. Moreover, life insurance is mainly granted on selected, unimpaired lives, whose chances of continuing in existence are not the same as those of the general population; so that, while all manner of information as to healthy or unhealthy districts and employments is valuable for the every-day guidance of an insurance manager, the mathematical foundation of his business rests on the general mortality of certain large classes scattered over a large extent of country, rather than on that of the entire population of a more limited region.

In its elementary form, the mortality table of the life insurance company starts with a certain number of persons living at the lowest age of which it takes cognizance, and shows the number of them who die during each succeeding year, with the successive remainders, or numbers of those living, at every age, until all are gone. From these data various probabilities and averages may be computed, such, for instance, as (1) the probability, at any age, of dying in the year next following, which probability is represented by the number dying during the given year divided by the number living at its beginning; (2) the probability, at any age, of dying during *any* given subsequent year of life; (3) the expectation of life, or average after-lifetime, of all who are alive at a given age; and (4) the "probable life," or *vie probable*, by which is meant the time that will elapse before just half of those living at the given age will be dead.

Halley, the astronomer, though not the first student of death-rates, published in 1693 the earliest English table that was a life-table, properly so called, having constructed it from the death records of the town of Breslau, in Silesia, which place was selected because its records included the *ages* of the dead.

The burial records of Northampton, from 1735 to 1780, furnished Dr. Price with the materials from which he constructed the Northampton table of mortality (1783), the first known to have been used for determining life-insurance premiums. Extensive monetary transactions have had this table for their basis, and it was at one time held in no little esteem; but later investigations have shown that it is far from correct, especially in showing too high a rate of mortality at the younger and middle ages. It will be noticed that these two tables were computed, or built up, from the ages of the dying, without information as to the actual number living at the various ages; this most necessary element was available in later times and made possible the construction of tables of much greater accuracy.

Professor Edward Wigglesworth, of Harvard University, constructed, also from bills of mortality, a life-table that appeared in 1789, not far from the time of Dr.

Price's labors, and was the first complete American table; it has been used by Massachusetts courts in valuing life contingencies.

The Carlisle life-table, based on records of the existing population, as well as of the deaths, was formed by Mr. Joshua Milne from material collected by Dr. John Heysham, in the town of Carlisle, from 1779 to 1787, and was published in 1815. Although based on an average population of only about eight thousand, and those not selected lives, the table has proved a surprisingly truthful guide to the many life insurance companies that have based their business upon it. It is irregular, and has such inconsistencies as a continuous lowering of the death-rate from age forty-six to age fifty, in which respects later tables are very much better.

Other widely known English tables have been those published in 1829, known as the Government tables, constructed by John Finlaison from data furnished by the records of some twenty-two thousand government annuitants; and several tables, especially the No. 3 of 1864, compiled by Dr. William Farr, chief of the statistical department of the English Registrar-General's office. This last was based on the English censuses of 1841 and 1851, and the deaths, 6,470,720 in number, of seventeen years, thus having the advantage of very extensive data for its foundation, and the distinction of being based on a large general population.

The Actuaries' or Combined Experience table was made up from the experience of seventeen British life insurance companies, and published in 1843. There is probably no source from which a more accurate record of ages and deaths can be had than from the books of an insurance company, for it is a matter of importance to the insured, as well as to the company, that his age should be correctly stated, and it would be only in the rarest instances that a death could pass unnoted. In making a mortality table, it is customary, after finding the number of years of life exposed at each age, and the ratio to that number of the actual number of deaths at the same age, to apply a process of graduating, by which the irregularities observable in passing from one age to another are smoothed out, as it were, without the general nature and effect of the death-ratios being changed; this facilitates the use of the table for mathematical and financial purposes, and may be considered as bringing it nearer what would be the average result of repeated and more extended observations. The graduating of the Actuaries' table was very skilfully done, and the table itself has been extensively used in this country, both by life insurance companies in their own calculations, and by State governments and insurance departments in fixing standards of liability for various purposes connected with the business.

A later compilation of the mortality experience of British companies, published in 1869, and known as the New Actuaries' or Twenty Companies' table, gave a striking confirmation of the general correctness of the table of 1843, just described.

It has been noticed that the favorable effect of the selection made by the companies, in only accepting applications for insurance from persons in good health and of approved record, has a very marked effect on the mortality of the first year or two of insurance, which, however, mostly disappears within four or five years from the time the examination is made. In connection with the construction of the New Actuaries' table, this point was investigated and a special table made (1872), based on observations from which the first five years of insurance on each life were excluded; this is designated the $H^{M(5)}$ (Healthy Males) table, and the resulting expectation of life may be seen and compared with others by reference to Table No. III., on page 25.

The mortality experiences of three large American

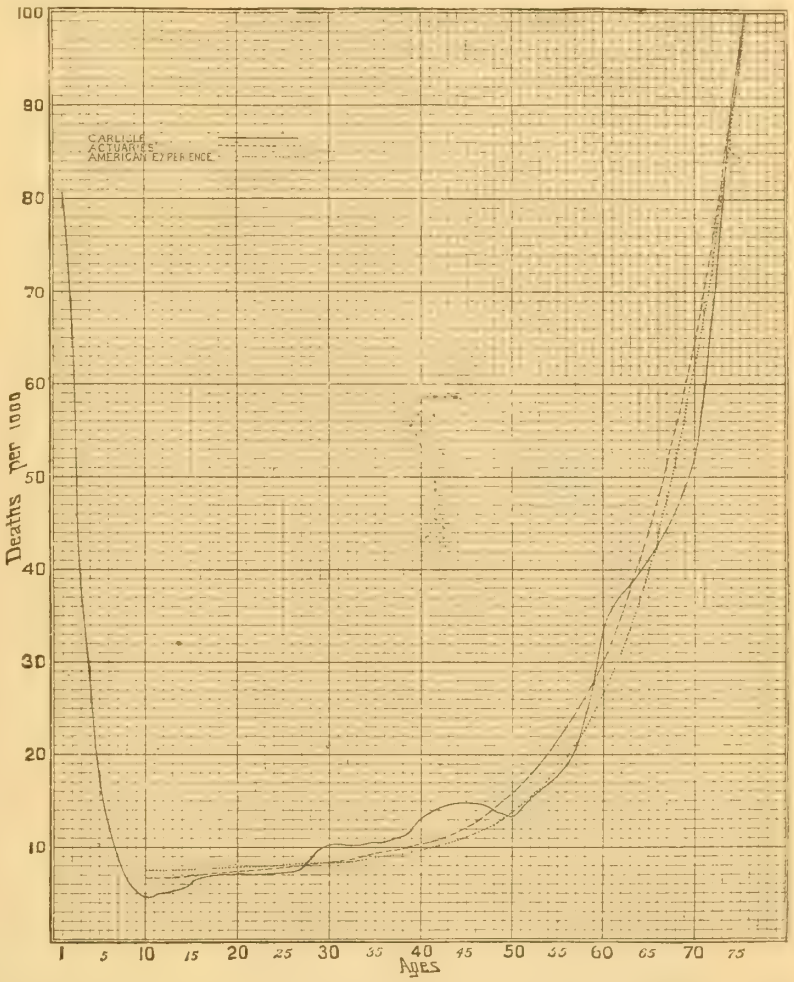

FIG. 2349.—Diagram of the Relative Mortality at Different Ages, according to Three Mortality Tables.

companies show, as a mean percentage, a rate of mortality for the first year of insurance that is twenty-six per cent. lower than that for all years at the same ages; for the second year of insurance the rate is fourteen per cent., and for the third year eight per cent. below the total rate experienced.

In one of these companies the mortality found by excluding the first five years of insurance from the reckoning was eleven per cent. higher than that found when all were included.

As in England, so also in America, there have been two important life-tables made from observations on insured lives: one by Sheppard Homans, Actuary of the Mutual Life Insurance Company of New York, based on the earlier experiences of that company, and published in 1868; and another, in 1881, by a committee (Levi W.

Meech, actuary in charge), from the combined experience of thirty American companies, covering more than a million policies.

The former is the insurance standard in nearly all cases in this country where the Actuaries' table is not employed.

These tables form convenient standards for testing the relative experience, as to death losses, of different institutions, and several American companies have published, at various times, the results of their observations, in elaborate form, and shown, as a result of judicious selection, a lighter mortality than that to be expected by any of the standard tables.

Table No. II., given herewith, includes the Carlisle, the Actuaries', and the American Experience mortality tables, and gives for each one (1) the number living at the several ages, (2) the annual decrements by death, and (3), in the form of a percentage, the ratio of dying to living at each age, or, in other words, the probability at that age of dying during the ensuing year. For example, at age 40 the Carlisle table gives a death-rate of 1.30 per cent., or 13 per 1,000, while by the Actuaries' table it is $\frac{1}{97.153}$ = 10.4 per 1,000, and by the American Experience 9.8 per 1,000. It will be noticed that, of those who are living at age 10, the largest number of deaths in any one year is, by the several tables, at ages 74, 72, and 73; and that the time when they are equally divided into living and dead occurs, by the Carlisle table, and by the Actuaries', between ages 63 and 64; and by the American Experience, between ages 64 and 65.

TABLE No. II.

Age.	Carlisle.			Actuaries' (17 Companies).			American Experience (Homans).		
	Living.	Dying.	Percentage of mortality.	Living.	Dying.	Percentage of mortality.	Living.	Dying.	Percentage of mortality.
0	10,000	1,539	15.39	.....	...	....	.....	...	....
1	8,461	682	8.06	.....	...	....	.....	...	....
2	7,779	505	6.49	.....	...	....	.....	...	....
3	7,274	276	3.79	.....	...	....	.....	...	....
4	6,998	201	2.87	.....	...	....	.....	...	....
5	6,797	121	1.78	.....	...	....	.....	...	....
6	6,676	82	1.23	.....	...	....	.....	...	....
7	6,594	58	.88	.....	...	....	.....	...	....
8	6,536	43	.66	.....	...	....	.....	...	....
9	6,493	33	.51	.....	...	....	.....	...	....
10	6,460	29	.45	100,000	676	.68	100,000	749	.75
11	6,431	31	.48	99,324	674	.68	99,251	746	.75
12	6,400	32	.50	98,650	672	.68	98,505	743	.75
13	6,368	33	.52	97,978	671	.68	97,762	740	.76
14	6,335	35	.55	97,307	671	.69	97,022	737	.76
15	6,300	39	.62	96,636	671	.69	96,285	735	.76
16	6,261	42	.67	95,965	672	.70	95,550	732	.77
17	6,219	43	.69	95,293	673	.71	94,818	729	.77
18	6,176	43	.70	94,620	675	.71	94,089	727	.77
19	6,133	43	.70	93,945	677	.72	93,362	725	.78
20	6,090	43	.71	93,268	680	.73	92,637	723	.78
21	6,047	42	.69	92,588	683	.74	91,914	722	.79
22	6,005	42	.70	91,905	686	.75	91,192	721	.79
23	5,963	42	.70	91,219	690	.76	90,471	720	.80
24	5,921	42	.71	90,529	694	.77	89,751	719	.80
25	5,879	43	.73	89,835	698	.78	89,032	718	.81
26	5,836	43	.74	89,137	703	.79	88,314	718	.81
27	5,793	45	.78	88,434	708	.80	87,596	718	.82
28	5,748	50	.87	87,726	714	.81	86,878	718	.83
29	5,698	56	.98	87,012	720	.83	86,160	719	.83
30	5,642	57	1.01	86,292	727	.84	85,441	720	.84
31	5,585	57	1.02	85,565	734	.86	84,721	721	.85
32	5,528	56	1.01	84,831	742	.87	84,000	723	.86
33	5,472	55	1.01	84,089	750	.89	83,277	726	.87
34	5,417	55	1.02	83,339	758	.91	82,551	729	.88
35	5,362	55	1.03	82,581	767	.93	81,822	732	.89
36	5,307	56	1.06	81,814	776	.95	81,090	737	.91
37	5,251	57	1.09	81,038	785	.97	80,353	742	.92
38	5,194	58	1.12	80,253	795	.99	79,611	749	.94
39	5,136	61	1.19	79,458	805	1.01	78,862	756	.96
40	5,075	66	1.30	78,653	815	1.04	78,106	765	.98
41	5,009	69	1.38	77,838	826	1.06	77,341	774	1.00
42	4,940	71	1.44	77,012	839	1.09	76,567	785	1.03
43	4,869	71	1.46	76,173	857	1.13	75,782	797	1.05
44	4,798	71	1.48	75,316	881	1.17	74,985	812	1.08
45	4,727	70	1.48	74,435	909	1.22	74,173	828	1.12
46	4,657	69	1.48	73,526	944	1.28	73,345	848	1.16
47	4,588	67	1.46	72,582	981	1.35	72,497	870	1.20
48	4,521	63	1.39	71,601	1,021	1.43	71,627	896	1.25
49	4,458	61	1.37	70,580	1,063	1.51	70,731	927	1.31
50	4,397	59	1.34	69,517	1,108	1.59	69,804	962	1.38
51	4,338	62	1.43	68,409	1,156	1.69	68,842	1,001	1.45
52	4,276	65	1.52	67,253	1,207	1.79	67,841	1,044	1.54
53	4,211	68	1.61	66,046	1,261	1.91	66,797	1,091	1.63
54	4,143	70	1.69	64,785	1,316	2.03	65,706	1,143	1.74
55	4,073	73	1.79	63,469	1,375	2.17	64,563	1,199	1.86
56	4,000	76	1.90	62,094	1,436	2.31	63,364	1,260	1.99
57	3,924	82	2.09	60,658	1,497	2.47	62,104	1,325	2.13
58	3,842	93	2.42	59,161	1,561	2.64	60,779	1,394	2.29
59	3,749	106	2.83	57,600	1,627	2.82	59,385	1,468	2.47
60	3,643	122	3.35	55,973	1,698	3.03	57,917	1,546	2.67
61	3,521	126	3.58	54,275	1,770	3.26	56,371	1,628	2.89
62	3,395	127	3.74	52,505	1,844	3.51	54,743	1,713	3.13
63	3,268	125	3.82	50,661	1,917	3.78	53,030	1,800	3.39
64	3,143	125	3.98	48,744	1,990	4.08	51,230	1,889	3.69
65	3,018	124	4.11	46,754	2,061	4.41	49,341	1,980	4.01
66	2,894	123	4.25	44,693	2,128	4.76	47,361	2,070	4.37
67	2,771	123	4.44	42,565	2,191	5.15	45,291	2,158	4.76
68	2,648	123	4.65	40,374	2,246	5.56	43,133	2,243	5.20
69	2,525	124	4.91	38,128	2,291	6.01	40,890	2,321	5.68
70	2,401	124	5.16	35,837	2,327	6.49	38,569	2,391	6.20
71	2,277	134	5.88	33,510	2,351	7.02	36,178	2,448	6.77
72	2,143	146	6.81	31,159	2,362	7.58	33,730	2,487	7.37
73	1,997	156	7.81	28,797	2,358	8.19	31,243	2,505	8.02
74	1,841	166	9.02	26,439	2,339	8.85	28,738	2,501	8.70
75	1,675	160	9.55	24,100	2,303	9.56	26,237	2,476	9.44
76	1,515	156	10.30	21,797	2,249	10.32	23,761	2,431	10.23
77	1,359	146	10.74	19,548	2,179	11.15	21,330	2,369	11 11
78	1,213	132	10.88	17,369	2,092	12.04	18,961	2,291	12.08
79	1,081	126	11.84	15,277	1,987	13.01	16,670	2,196	13.17
80	953	116	12.17	13,290	1,866	14.04	14,474	2,091	14.45
81	837	112	13.38	11,424	1,730	15.14	12,383	1,964	15.86
82	725	102	14.07	9,694	1,582	16.32	10,419	1,816	17.43
83	623	94	15.09	8,112	1,427	17.59	8,603	1,648	19.16
84	529	84	15.88	6,685	1,268	18.97	6,955	1,470	21.14
85	445	78	17.53	5,417	1,111	20.51	5,485	1,292	23.56
86	367	71	19.35	4,306	958	22.25	4,193	1,114	26.57
87	296	64	21.62	3,348	811	24.22	3,079	983	30.30
88	232	51	21.98	2,537	673	26.53	2,146	744	34.67
89	181	39	21.55	1,864	545	29.24	1,402	555	39.59
90	142	37	26.06	1,319	427	32.37	847	385	45.45
91	105	30	28.57	892	322	36.10	462	246	53.25
92	75	21	28.00	570	231	40.53	216	157	63 43
93	54	14	25.93	339	155	45.72	79	58	73.42
94	40	10	25.00	184	95	51.63	21	18	85.71
95	30	7	23.33	89	52	58.43	3	3	100.00
96	23	5	21.74	37	24	64.86	.....	...	....
97	18	4	22.22	13	9	69.23	.....	...	....
98	14	3	21.43	4	3	75.00	.....	...	....
99	11	2	18.18	1	1	100.00	.....	...	....
100	9	2	22.22	.....	...	....	.....	...	....
101	7	2	28.57	.....	...	....	.....	...	....
102	5	2	40.00	.....	...	....	.....	...	....
103	3	2	66.67	.....	...	....	.....	...	....
104	1	1	100.00	.....	...	....	.....	...	....

The percentage of mortality in childhood, by a different authority (William Farr: English Life-Table. Tables of life-times, annuities, and premiums. With an introduction. London: Longman, 1864), is as follows:

English Life Table, No. 3 (Farr, 1864).

Age.	Percentage of Mortality.	
	Males.	Females.
0	16.36	13.47
1	6.43	6.19
2	3.55	3.54
3	2.38	2.42
4	1.78	1.77
5	1.36	1.33
6	1.08	1.05
7	.92	.91
8	.76	.77
9	.65	.66
10	.56	.59

The death-rates given in Table No. II. are shown in a different way by the diagram on page 23, where each age, from 1 to 75, is represented by a vertical line, on which is set off a distance from the bottom that represents the relative mortality at that age; the points thus found on these lines are connected by a curved line, and the resulting figure shows very clearly the general similarity of the three tables, as well as their characteristic points of difference.

The ages are shown by figures at the foot of the diagram, and the deaths to 1,000 persons by figures at the side.

The irregularity of the Carlisle table is as noticeable as the gradual way in which the rates change in the other two, while the general track of all three lines is a narrow one throughout, tending sharply upward from the fifth decade.

It may be seen that the Carlisle mortality at age 1 is the same as that again reached between ages 73 and 74; that from ages 10 to 27 its rate is decidedly lower, and from 28 to 47 higher, than by either of the other tables. The rates by the Actuaries' table are lower than by the American Experience from age 10 to age 30, and higher from age 31 to age 77.

Table No. III.—Expectation of Life by Various Mortality Tables.

Age.	Carlisle.	English Life, No. 3. (Farr).		Actuaries' (17 Companies).	Actuaries' (20 Companies), 1869.		American Experience (Humans)	American Experience (30 Companies), 1881.	
		Male.	Female.		Male.	$H^{M(5)}$.		Male.	Female.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0..	38.72	39.91	41.85	.....	.....	.....	.....	.....	.....
1..	44.67	46.65	47.31	.....	.....	.....	.....	.....	.....
2..	47.55	48.83	49.40	.....	.....	.....	.....	.....	.....
3..	49.81	49.61	50.20	.....	.....	.....	.....	.....	.....
4..	50.76	49.81	50.43	.....	.....	.....	.....	.....	.....
5..	51.24	49.71	50.33	.....	.....	.....	.....	.....	.....
6..	51.16	49.39	50.00	.....	.....	.....	.....	.....	.....
7..	50.79	48.92	49.53	.....	.....	.....	.....	.....	.....
8..	50.24	48.37	48.98	.....	.....	.....	.....	.....	.....
9..	49.57	47.74	48.35	.....	.....	.....	.....	.....	.....
10..	48.82	47.05	47.67	48.36	50.29	48.46	48.72	49.99	48.05
11..	48.04	46.31	46.95	47.68	49.54	47.66	48.08	49.32	47.21
12..	47.27	45.54	46.20	47.01	48.73	46.82	47.45	48.64	46.40
13..	46.50	44.76	45.44	46.33	47.89	45.96	46.80	47.95	45.64
14..	45.74	43.97	44.66	45.64	47.03	45.09	46.16	47.26	44.91
15..	44.99	43.18	43.90	44.96	46.16	44.23	45.50	46.57	44.19
16..	44.27	42.40	43.14	44.27	45.29	43.37	44.85	45.88	43.48
17..	43.57	41.64	42.40	43.58	44.44	42.53	44.19	45.18	42.79
18..	42.87	40.90	41.67	42.88	43.61	41.72	43.53	44.48	42.12
19..	42.16	40.17	40.97	42.19	42.82	40.94	42.87	43.78	41.46
20..	41.46	39.48	40.29	41.49	42.06	40.22	42.20	43.07	40.82
21..	40.75	38.80	39.63	40.79	41.33	39.55	41.53	42.36	40.19
22..	40.03	38.13	38.98	40.09	40.60	38.93	40.85	41.65	39.56
23..	39.31	37.46	38.33	39.39	39.88	38.33	40.17	40.93	38.96
24..	38.58	36.79	37.68	38.68	39.15	37.74	39.49	40.21	38.38
25..	37.86	36.12	37.04	37.98	38.41	37.15	38.81	39.49	37.80
26..	37.13	35.44	36.39	37.27	37.66	36.54	38.12	38.77	37.23
27..	36.40	34.77	35.75	36.56	36.91	35.90	37.43	38.04	36.66
28..	35.68	34.10	35.10	35.86	36.16	35.26	36.73	37.31	36.08
29..	34.99	33.43	34.46	35.15	35.42	34.60	36.03	36.58	35.49

Table No. III.—*Continued.*

Age.	Carlisle.	English Life, No. 3 (Farr).		Actuaries' (17 Companies).	Actuaries' (20 Companies), 1869.		American Experience (Humans)	American Experience (30 Companies), 1881.	
		Male.	Female.		Male.	HM(5).		Male.	Female.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
30..	34.34	32.76	33.81	34.43	34.68	33.93	35.33	35.85	34.89
31..	33.68	32.09	33.17	33.72	33.95	33.24	34.63	35.12	34.29
32..	33.02	31.42	32.53	33.01	33.21	32.54	33.92	34.38	33.69
33..	32.36	30.74	31.88	32.30	32.48	31.84	33.21	33.65	33.06
34..	31.68	30.07	31.23	31.58	31.75	31.13	32.50	32.91	32.42
35..	31.00	29.40	30.59	30.87	31.02	30.42	31.78	32.17	31.78
36..	30.32	28.73	29.94	30.15	30.29	29.72	31.07	31.43	31.13
37..	29.63	28.06	29.29	29.44	29.56	29.03	30.35	30.70	30.47
38..	28.95	27.39	28.64	28.72	28.84	28.34	29.62	29.96	29.81
39..	28.27	26.72	27.99	28.00	28.12	27.65	28.90	29.22	29.16
40..	27.61	26.06	27.34	27.28	27.40	26.96	28.18	28.48	28.48
41..	26.97	25.39	26.69	26.56	26.68	26.26	27.45	27.75	27.82
42..	26.34	24.73	26.03	25.84	25.96	25.56	26.72	27.01	27.15
43..	25.71	24.07	25.38	25.12	25.23	24.85	26.00	26.28	26.45
44..	25.09	23.41	24.72	24.40	24.51	24.14	25.27	25.55	25.74
45..	24.45	22.76	24.06	23.69	23.79	23.43	24.54	24.82	25.02
46..	23.81	22.11	23.40	22.97	23.08	22.73	23.81	24.09	24.30
47..	23.17	21.46	22.74	22.27	22.38	22.04	23.08	23.38	23.57
48..	22.50	20.82	22.08	21.56	21.68	21.36	22.36	22.66	22.83
49..	21.81	20.17	21.42	20.87	20.99	20.68	21.63	21.95	22.08
50..	21.11	19.54	20.75	20.18	20.31	20.02	20.91	21.24	21.33
51..	20.39	18.90	20.09	19.50	19.63	19.35	20.20	20.54	20.59
52..	19.68	18.28	19.42	18.82	18.95	18.70	19.49	19.84	19.87
53..	18.97	17.67	18.75	18.16	18.28	18.05	18.79	19.15	19.15
54..	18.28	17.06	18.08	17.50	17.62	17.41	18.09	18.47	18.44
55..	17.58	16.45	17.43	16.86	16.96	16.77	17.40	17.80	17.73
56..	16.89	15.86	16.79	16.22	16.32	16.14	16.72	17.13	17.03
57..	16.21	15.26	16.17	15.59	15.68	15.51	16.05	16.47	16.35
58..	15.55	14.68	15.55	14.97	15.05	14.90	15.39	15.83	15.67
59..	14.92	14.10	14.94	14.37	14.44	14.29	14.74	15.19	15.02
60..	14.34	13.53	14.34	13.77	13.83	13.69	14.10	14.56	14.37
61..	13.82	12.96	13.75	13.18	13.24	13.11	13.47	13.94	13.73
62..	13.31	12.41	13.17	12.61	12.66	12.54	12.86	13.34	13.10
63..	12.81	11.87	12.60	12.05	12.10	11.98	12.26	12.74	12.49
64..	12.30	11.34	12.05	11.51	11.55	11.44	11.67	12.16	11.90
65..	11.79	10.82	11.51	10.97	11.01	10.92	11.10	11.60	11.31
66..	11.27	10.32	10.98	10.46	10.49	10.41	10.54	11.04	10.74
67..	10.75	9.83	10.47	9.96	9.98	9.91	10.00	10.50	10.19
68..	10.23	9.36	9.97	9.47	9.48	9.41	9.47	9.97	9.65
69..	9.70	8.90	9.48	9.00	8.98	8.92	8.97	9.46	9.13
70..	9.17	8.45	9.02	8.54	8.50	8.44	8.48	8.97	8.62
71..	8.65	8.03	8.57	8.10	8.03	7.98	8.00	8.49	8.13
72..	8.16	7.62	8.13	7.67	7.58	7.53	7.55	8.02	7.65
73..	7.72	7.22	7.71	7.26	7.15	7.10	7.11	7.57	7.20
74..	7.33	6.85	7.31	6.86	6.75	6.70	6.68	7.14	6.76
75..	7.00	6.49	6.93	6.48	6.38	6.33	6.27	6.72	6.34
76..	6.69	6.15	6.56	6.11	6.02	5.98	5.88	6.32	5.93
77..	6.40	5.82	6.21	5.76	5.67	5.64	5.49	5.93	5.55
78..	6.11	5.51	5.88	5.42	5.34	5.31	5.11	5.57	5.18
79..	5.80	5.21	5.56	5.09	5.03	5.00	4.74	5.21	4.82
80..	5.51	4.93	5.26	4.78	4.72	4.70	4.39	4.87	4.49
81..	5.20	4.66	4.98	4.48	4.43	4.41	4.05	4.55	4.17
82..	4.93	4.41	4.71	4.18	4.17	4.15	3.71	4.24	3.88
83..	4.65	4.17	4.45	3.90	3.93	3.91	3.39	3.95	3.59
84..	4.39	2.95	4.21	3.63	3.71	3.69	3.08	3.67	3.33
85..	4.13	3.73	3.98	3.36	3.51	3.48	2.77	3.40	3.08
86..	3.90	3.53	3.76	3.10	3.31	3.27	2.47	3.14	2.84
87..	3.71	3.34	3.56	2.84	3.10	3.05	2.18	2.89	2.62
88..	3.60	3.16	3.36	2.59	2.88	2.83	1.91	2.64	2.42
89..	3.47	3.00	3.18	2.35	2.63	2.58	1.66	2.39	2.23
90..	3.28	2.84	3.01	2.11	2.36	2.31	1.42	2.17	2.05
91..	3.26	2.69	2.85	1.89	2.08	2.02	1.19	1.98	1.89
92..	3.37	2.55	2.70	1.67	1.80	1.73	.98	1.81	1.73
93..	3.48	2.41	2.55	1.47	1.50	1.43	.80	1.64	1.59
94..	3.53	2.29	2.42	1.28	1.20	1.15	.64	1.49	1.46
95..	3.53	2.17	2.29	1.12	.93	.86	.50	1.34	1.34
96..	3.46	2.06	2.17	.99	.68	.50	...	1.18	1.23
97..	3.28	1.95	2.06	.89	.50	...	...	1.03	1.09
98..	3.07	1.85	1.96	.75	...	...	...	.83	.93
99..	2.77	1.76	1.86	.50	...	...	...	.50	.50
100..	2.28	1.68	1.76	...	...	...	...	..	...
101..	1.79	....	....	...	...	...	...	...	...
102..	1.30	....	....	...	...	...	...	...	...
103..	.83	....	....	...	...	...	...	...	...
104..	.50	....	...	...	...	...	...	...	...

Table No. III. shows the expectation of life, or average after lifetime, at each age, by nine different standards. Columns (1), (4), and (7) are from the figures given in Table No. II.; columns (2) and (3) are based on Dr. Farr's calculations for male and female lives, respectively; columns (5) and (6) are according to the "New Actuaries'" mortality for male lives, and for lives not newly insured, as already explained; while in columns (8) and (9) the results of Mr. Meech's computations from the statistics of thirty American insurance companies are given. These various "expectations" are given as being of interest to the general student, and as showing the remarkable agreement that exists among the results of such diverse investigations, as well as their interesting differences; but it should be understood that, contrary to a very popular idea, the "expectation" is not the element from which life insurance premiums, annuity values, and so on, are, or can be, correctly determined. These must be calculated by a method that takes account of the precise probability for each year that the death will occur in that year, as true results cannot be reached, where compound interest is involved, by averaging.

It will be seen that in the general English population, columns (2) and (3), the expectation is greater for females than for males, and this agrees with the conclusions of observers elsewhere; but it is a notable fact that companies insuring both sexes have often had just the opposite experience, and the expectation shown in column (9) is less than that in column (8) for all but nineteen ages, at which it is equal or slightly higher. This is presumably because the classes of women whose lives are offered for insurance are not, sanitarily, a fair average of the population; and because of the greater difficulty of getting a medical examination that shall truly discriminate.

Oscar B. Ireland.

MOSS, CORSICAN (*Mousse de Corse*, Codex Med.; *Helminthocorton*, Worm Moss, etc.). The alga properly known by this name is *Ulsidium Helminthocorton* Ag.; Order, *Florideæ*, a small, brown, marine plant, with a tufted thallus of simple or sparsely forked, pointed, thread-like branches, from three to four centimetres long. It is a native of the Mediterranean Sea, and was formerly collected on the shores of the island of Corsica, from which it receives its name. The anthelmintic mixture, however, still to be found in European pharmacies under this name, includes, besides this, several other related algæ, among which species of *Ceramium*, *Polysiphonia*, *Gigartina*, etc., are commonly met with. There is nothing unusual in the composition of any of the above to explain their former reputation as vermicides—iodine, bromine, soda, etc., in composition, and an abundance of vegetable jelly.

As a medicine Corsican moss is of the past. A decoction is occasionally given to children as a domestic remedy for lumbrici, etc.

Allied Plants.—See Moss, Irish, etc.

Allied Drugs.—The various mucilages and starches and their sources. The anthelmintic power of this substance is doubtful. See Koosso. *W. P. Bolles.*

MOSS, ICELAND (*Cetraria*, U. S. Ph., Br. Ph.; *Lichen Islandicus*, Ph. G.; *Lichen d'Islande*). The thallus of *Cetraria islandica* Acharius; Order, *Lichenes*. This is a good-sized terrestrial lichen, with an upright or ascending, long and narrow, leathery, wavy-margined, olive-green thallus, several times dichotomously branched or irregularly fan-shaped, with linear or cuneiform lobes. *Apothecia* shield-shaped on the upper surface of the thallus. It grows in great abundance on the surface of the ground in open woods and heaths, and on mountain sides, in the arctic and the colder temperate regions of both hemispheres.

It is a valuable pasture plant in the extreme North, and is also employed as an article of human food in parts of northern Europe. Its medical employment is one or two centuries old.

Dried Cetraria is thus described: "From two to four inches (5 to 10 centimetres) long, foliaceous, with fringed and channelled lobes, brownish above, whitish beneath, brittle and inodorous; when softened in water, cartilaginous, and having a slight odor; its taste is mucilaginous and bitter."

Composition.—Sixty or seventy per cent. is *lichenin*, a starch-like substance found also in many other lichens.

Fig. 2350.—Iceland Moss. (Luerssen.)

It is structureless, soluble in boiling water, gelatinizing upon cooling, and yielding, when moist, the starch reaction with iodine. Chemical composition, $C_{12}H_{20}O_{10}$, same as that of starch. The bitter principle, *cetraric acid* or *cetrarin*, crystallizes in fine needles. It is nearly insoluble in water.

Use.—Iceland moss is a very useful demulcent, and has gentle tonic qualities, for which it is indebted to the two active principles above mentioned. It has no specific action upon the bronchi or lungs, and its value in bronchitis, etc., for which it is mostly prescribed, must be due to its combined demulcent and tonic actions. Dose, indefinite; a decoction is officinal.

Allied Plants.—See Ergot.

Allied Drugs.—See next article. *W. P. Bolles.*

MOSS, IRISH (*Chondrus*, U. S. Ph.; *Carrageen*, Ph. G.; *Carragahaen*, *Carrageen*, ou *Mousse perlée*, Codex

Fig. 2351.—Irish Moss. (Luerssen.)

Med.), *Chondrus crispus* Lyngb.; Order, *Florideæ*, *Algæ*. A reddish-brown or purplish alga, with a flat, many-

times forked or lobed thallus, of very variable appearance, sometimes with broad, flat, wedge-shaped, wavy, and incised, margined lobes, at other times with linear, roundish, blunt, or emarginate ones. It is from five to twenty centimetres high, of a translucent, gelatinous consistence. The fructifications (cystocarps) are imbedded in the substance of the thallus, along the smaller branches, where they can be felt as little, wartlike indurations beneath the surface. This alga grows abundantly along the rocky shores of Western Europe and Eastern America, that is, on each side of the North Atlantic. It has for a long time served as an innutritious food, and as the basis of vegetable jellies for the table; it is also, in some localities, fed to cattle, and used as a stuffing for cheap mattresses. Its employment in medicine is of recent date, and entirely unimportant. It is collected on the coast of Ireland and elsewhere in Europe, also upon that of New England and elsewhere in America. For medical or table use it is bleached in the sun, washed, and dried.

Description.—Irish moss shrinks considerably in drying, and if exposed to the sun, or repeatedly wet and dried, bleaches to a yellow color. It is, when dry, hard, horny, and brittle, but resumes its original size and consistence after long soaking in water. In boiling water it almost completely dissolves. Taste mawkish, mucilaginous, and more or less saline, according to the thoroughness with which it has been cleansed. It will make a stiff jelly with twenty or thirty times its weight of water.

Composition.—Chondrus consists chiefly of a mucilage, common also to many other algæ, swelling and nearly dissolving in water, and drying to a hard, transparent substance. It is precipitated by alcohol, and holds tenaciously about one-seventh its weight of mineral matter. It contains, in common with other marine algæ, minute quantities of iodine and bromine compounds.

Medical Employment.—For colds, coughs, and especially acute pharyngitis, a thin mucilage (decoction) made of Irish moss is a popular household remedy, and corresponds exactly with the mucilage of slippery elm and flaxseed, made in the same way. It may be sweetened and flavored with lemon. Boiled with milk it makes an agreeable jelly ("blanc-mange"), often used as a sick diet, whose value depends on the milk.

Allied Plants.—Several species of *Gigartina*, which have the same properties, are employed in different parts of the world for the same purposes as Carragheen. One of these, *G. Spinosa* Greville, the agar-agar of China and the East Indies, has lately come into notice as furnishing a stiff jelly of valuable qualities to the bacteriologists.

Allied Drugs.—Slippery elm, flaxseed, starch, and the gums arabic, tragacanth, etc. *W. P. Bolles.*

MOTOR DEPRESSANTS. Under this heading will be described those medicinal agents which possess the power of directly influencing the nervous mechanisms which preside over motion. The term is more commonly applied to the drugs that directly depress the motor activity of the spinal cord. That the latter is a too restricted meaning of the term is shown by the fact that our most powerful and most useful motor depressant—bromide of potassium—has a direct depressant action on the cerebral motor convolutions, as well as on the motor centres in the medulla. The great usefulness of this drug in epilepsy is undoubtedly dependent on its cerebral action, and not on its spinal motor depressant influence.

The different bromides, calabar bean, gelsemium, conium, and curare are the leading direct motor depressants. Other agents, such as the nitrite of amyl, lobelia, chloral hydrate, and tobacco, although motor depressant, are only so in a secondary sense. The depressant action of the former group only will be here dealt with.

Calabar Bean.—When a large dose of this drug is administered to one of the lower animals, general muscular tremor sets in, and almost immediately afterward the animal falls to the ground in a state of complete muscular flaccidity. If the dose has been large there is complete abolition of reflex action. The tremors continue during the whole period of muscular paralysis. The paralysis and abolition of reflex activity are due to the direct action of the drug on the spinal cord, and not to any action on the cerebrum, nerves, or muscles. We have both positive and negative evidence of the truth of this statement. If the paralysis were caused by the direct action of the drug on the muscles, these structures would not respond later to galvanic stimulation, as they are found to do. That the paralysis induced by calabar bean is not caused by an action on the spinal nerves is proven by the fact that, long after the production of the paralysis, and even after death, the different spinal nerves will conduct impressions to their tributary muscles. A cerebral origin of the paralysis is eliminated by the fact that it occurs in the frog after the removal of the brain.

We have, by a train of negative experimental evidence, shown that the paralysis is spinal. We have, however, positive evidence that this conclusion is correct. If all the vessels going to the posterior portion of the spinal cord of an animal be ligatured, and if then calabar bean be injected, it will be found that the anterior limbs become paralyzed, while the posterior escape. The portion of cord to which the drug has had access is depressed, while that part from which it has been cut off by the temporary ligature retains its functional activity. We therefore have conclusive proof that the motor depressant action of calabar bean is due to a direct influence that it exerts on the spinal cord. Further, it is universally believed that this action is brought about by the direct influence of the drug on the ganglion-cells of the anterior cornua, but in what way it depresses the functional activity of these cells is not known.

Bromide of Potassium.—The range of action of bromide of potassium as a motor depressant is much more extensive than that of calabar bean. We have just seen that this action in the case of the latter drug is confined to the spinal cord; while, as will be presently shown, the bromide affects, in addition, the cerebral motor convolutions and the afferent nerves. Both have a depressing influence on the motor centres in the medulla.

When bromide of potassium is injected into a frog in single small doses, the first effect is the production of spasms, but these soon give place to a condition of muscular relaxation and total abolition of reflex action. Voluntary movements often occur, however, even after the total abolition of all reflex action. This fact can be taken as evidence that the muscular relaxation is not wholly caused by a direct action on the motor centres of the brain and spinal cord. Even after the loss of reflex action the muscles respond to the direct stimulation of them by a galvanic current, a proof that the paresis is not due to muscular poisoning by the bromide. That the motor nerves take no part in the production of the paralysis is shown by the following experiment: If the vessels of the hind extremity are first securely tied, and the animal is then poisoned, the paresis occurs in the hind extremities as well as in other parts of the body.

The depressant action of bromide of potassium on the afferent nerves is a matter of daily experience. The peripheral terminations of the afferent nerves are more powerfully depressed than any other part of their course. It has recently been demonstrated by Albertoni that this drug possesses a marked action in depressing the irritability of the cerebral motor convolutions. So marked is this action that, in an animal fully under the influence of the drug, it takes a much more powerful faradic current to produce contraction of the muscles governed by these centres, when irritated, than is the case in an animal not under its influence. Professor Albertoni conducted his experiments in the following manner: He removed that portion of the skull in dogs, corresponding to the motor areas of the face and extremities, and ascertained the weakest current from a faradic battery that was able to induce contraction of the muscles. The wound was then brought together and sufficient time allowed for the recovery of the animal, which was usually very rapid. He then had administered to the animal, in its food, bromide of potassium in doses of from 2 to 3 Gm. (30 to 45 grains) daily. After several days,

the psychomotor zone of the opposite hemisphere was laid bare, in order to prove its irritability, and to compare it with the state of reaction, previously ascertained, of the other hemisphere. The uninjured side was made choice of, for the reason that, on account of the interference previously with the opposite hemisphere, the inflammatory thickening of the membranes would influence the results. In every case in which Professor Albertoni performed the above experiment, he found a marked difference in the readiness with which the motor zone reacted to the faradic current before and after the administration of the bromide. Previous to the administration of the drug, spasm of the facial muscles and extremities could be induced when the secondary spiral was one hundred and ten millimetres removed from the primary spiral; a distance of seventy millimetres was required to induce a corresponding spasm in the same parts after the administration of the bromide. These experiments prove beyond doubt that bromide of potassium possesses a marked depressant action on the cerebral motor area. They also throw light on the mode in which it influences epileptic paroxysms.

The depressant action of bromide of potassium on the motor centres in the medulla, especially on the respiratory centre, is too well known to require any detailed description here. Its depressant action on the spinal reflex mechanism is well known, and daily made practical use of in the convulsive disorders of childhood.

According to the severity with which the different portions of the nervous system are affected by this drug, they may be arranged in the following order: 1, Spinal cord; 2, cerebral motor area; 3, afferent nerves; 4, medullary motor centres. When the bromide is pushed to the extent of complete saturation of the system, it also involves the special senses in its depressant action, but as these are extra-therapeutical effects, no notice will be taken of them in this connection.

CURARE.—When a small quantity of curare is injected subcutaneously into one of the lower animals, general muscular paralysis ensues, the only muscle escaping being the heart muscle. From a full dose the paralysis is so profound that the animal lies apparently dead. The heart, however, can be found beating vigorously, and, if any artery be cut across, the blood jets forcibly from it. An animal can be kept alive for an indefinite length of time, after an otherwise fatal dose, provided artificial respiration be maintained.

How is the paralysis caused by curare produced? Paralysis may depend on interference directly with the functions of the muscles, or with those of the motor nerves which supply the muscles, or it may be due to direct involvement of the nerve-centres.

Bernard was the first to show that curare did not produce paralysis by a direct action on the muscles, by demonstrating that they readily contracted in a frog killed by this poison. On testing the motor nerves with a galvanic current, however, he found that there was no contraction in their tributary muscles; and to ascertain whether the curare acted on the nerve-trunks or on their terminations in the muscles, he proceeded in the following way: He prepared a muscle of the hind limb of a frog, leaving a portion of the sciatic nerve attached to it. He then steeped the trunk of the nerve in a solution of the poison, and on testing its functional power he found it unimpaired. When, however, he soaked the muscle in the solution, so that the curare came into contact with the ends of the nerve, paralysis was produced. The action of the poison was thus localized to the ends of the nerve in the muscle. To ascertain whether other portions of the nervous system suffered in a similar way, Bernard resorted to the following ingenious experiment. Owing to the paralytic condition of the motor nerves, there is no means of communication between the nerve-centres and the muscles. These centres might or might not be affected. In order to prove whether they suffered or not, it was necessary to exclude the limb from the action of the poison, so that, this limb retaining its power to move, we should have an index of what was going on in the nerve-centres. The artery and vein in the leg of a frog were accordingly tied, and then the curare was injected under the skin of the back. The poison was carried to every part of the body except the limb whose vessels were ligatured. When the whole animal was poisoned it was found that pinching of the skin produced no movements in any part of the body. In the frog with the occluded vessels no movements took place in any part except in the limb which the poison did not reach, no matter how severe the pinching was. From this it is clear that the spinal cord and sensory nerves retain their functions, and that the paralytic action of curare is due to the influence that it exerts on the terminations of the motor nerves.

Curare is also a powerful depressant of the respiratory centre in the medulla.

GELSEMIUM.—The motor depressant action of gelsemium is more easily induced in the lower animals than in man. It is only in overdoses that this action is present in a marked degree in the latter. Reference is here made to a general motor depressant effect, and not to the local palsies that are almost constantly seen even after medium doses.

The general paralysis resulting from gelsemium has been proved conclusively to be due to a direct action on the spinal cord. The double vision, ptosis, dilatation of the pupils, and paresis of accommodation resulting from the internal administration of full medicinal doses of this drug are due to a direct influence on the peripheral nervous structures. The double vision is generally caused by paresis of the sixth nerve, which supplies the external rectus muscle. The dilatation of the pupils, the ptosis, and the paralysis of accommodation are due to the action of the gelsemium on the endings of the third nerve. The glossoplegia which is seen after full doses of this drug is due to the action on the hypoglossal. The drooping of the lower jaw is explainable by paresis of those branches of the fifth nerve supplying the elevators of the lower jaw. It is a curious fact that gelsemium has a paralyzing influence on the sensory terminations of the fifth nerve also, and especially of those branches going to the lower jaw.

The depressant action of gelsemium on the bulbar motor centres is too well known to need any detailed description.

CONIUM.—The marked motor depressant action of this drug has been known since time immemorial. It was the means employed by the ancient Greeks to rid themselves of their political prisoners. The illustrious Socrates was poisoned by the "hemlock cup."

Conium is a marked motor depressant, this action being due to the alkaloid conia. Convulsions are, however, not infrequent in cases of conium poisoning. This is explained by the fact that the plant, in addition to conia, contains a second alkaloid, which has a stimulating action on the spinal cord. This alkaloid has received the name of methyl-conia. Conia and methyl-conia bear a close resemblance in their pharmacology to physostigmine and calabarine. The motor depressant action of conium is certainly not due to an action on the muscles, for these respond to stimulation as they do in health; neither is it due to any influence on the spinal cord, for if a limb of a frog is ligatured (artery and vein) and the animal then poisoned, movements take place in those parts which have been ligatured, thus showing that the cord is able to transmit impressions. The action is brought by an influence exerted on the whole course of the motor nerves. The nerve-endings in the muscles are more profoundly affected, however, than any other portions of the nerves.

James Stewart.

MOUNTAIN CLIMATES. So much attention has been latterly bestowed upon the remedial and even curative effects derivable from recourse to mountainous regions, and to elevated plateaux, that a special article, which shall treat briefly of the meteorological peculiarities of such regions and of their claims as therapeutic resorts, may well find a place in the present work. Accordingly the writer has not contented himself with what has been said respecting the climate and climato-therapy of elevated regions in the general articles on Climate and on

Health Resorts, as well as in a number of the special articles which describe individual resorts, but, in addition to such scattered comments, he has deemed that it would be well to present to readers of the HANDBOOK a special article dealing solely with the subject of mountain climates, and to which direct reference may be made as to an epitomized treatise on such climates, to a condensed and, in some respects, superficial statement of our present imperfect knowledge of them and of their physiological and therapeutic effects.

The subject of mountain climates appears to be the chief battle-ground to-day of writers on climato-therapy. We shall make no attempt to lead our readers into the thick of the fray. A "reference handbook" is no place for the presentation of a multitude of conflicting and imperfectly digested theories; and even were he inclined to do so, the writer has neither time nor space for making such presentation. Scanty observation, and hasty attempts to reach conclusions from insufficient data in a matter of great complexity, are the chief causes of the controversy raging over the subject of mountain climates; and in this department of medicine it may be accepted as pre-eminently true, that where controversy is, there is ignorance. The greater part of the controversy over mountain climates relates to the *modus operandi* of the meteorological peculiarities existing in certain of the factors of the climate of elevated regions, and notably in that peculiarity which is most characteristic of such regions—to wit, the diminution in atmospheric pressure. There is, of course, no controversy as to the existence of a relatively light weight of atmosphere overlying points of the earth's surface which are raised above the general level; neither is there much room for controversy as to the other special features of climate found in mountainous districts and on plateaux. Moreover, it is generally recognized that the climates of such regions possess very valuable therapeutic power, and lead to beneficial results in many cases of disease. The precise nature of this power is not yet fully understood; and it necessarily follows that when we come to consider its method of operation upon the complex human organism, whether such organism be in a normal or healthy, or in an abnormal or unhealthy condition, we are launched forth at once upon a very sea of disputation and doubt. The writer frankly and unblushingly confesses that a voyage upon such a sea has for him no attractions, and that it exercises no beneficial effect upon his mental constitution. In his ventures upon its waters he has been solely in search of such flotsam and jetsam of practical fact as he might be able to collect for his readers; and, thanks chiefly to the pilotage of Dr. Hermann Weber, he believes that he has found a few fragments of this kind.

The first step toward a consideration of mountain climates is the determination of what we mean by mountains. In this article our chief occupation shall be with what are commonly, but somewhat pleonastically, termed "high altitudes;" that is, with elevations above sea-level which equal or exceed 5,000 feet, when lying within the middle portion of the temperate zone, and which, when lying within the tropics, exceed 8,000 feet or thereabout. But, in addition to these, it will be our duty to give some consideration to places of less elevation, including such as are commonly regarded as "mountain resorts;" that is, for the United States and for Middle and Southern Europe, such as lie from about 2,000 to 5,000 feet above sea-level.

Mere elevation, unless very considerable in degree, will not entitle a region to be regarded as one properly eligible for discussion in this article. Thus, an inland place lying on a plateau at a height of less than 3,000 or 4,000 feet above sea-level can hardly be looked upon as one which, from a climato-therapeutic point of view, possesses the peculiarities of a mountain climate. On the other hand, a point lying within the limits of a distinctly mountainous region, even when itself standing not more than 2,000 feet above the sea (nay, sometimes much less than this), may justly be classed as a mountain resort. Diminished atmospheric density is a meteorological peculiarity belonging in common to both these two classes of places, but other important properties of a truly mountain climate which are generally found in the latter will uniformly be lacking in the former class. The temperature, rainfall, and humidity of a place lying close to or among mountains are all greatly modified by the precise topographical relations there existing. Thus, situation upon the windward side of a mountain range is a very different thing from situation upon its leeward side; situation at the bottom of a deep, narrow valley which runs from east to west is a very different thing, climatically, from situation in a precisely similar valley of which the direction is from north to south; situation in the bed of a wide valley is a different thing from situation at the bottom of a narrow one; location part way up the side of one of the mountain-walls which enclose a valley is quite different from location on the top of such a wall or at its base, and two places lying equally elevated above sea-level, but on opposite sides of a valley, will differ materially as to the climatic advantages and disadvantages which they respectively possess as residences for invalids. The nature of the soil and the character of the vegetation, also, exercise no little determining influence upon the climate of places lying in the midst of, or in close proximity to, a mountainous region. Valley-bottoms are apt to be damper and more subject to fogs than are the sides or tops of the surrounding hills. Not infrequently they are colder at night than are points lying part way up the sides of the valley-walls. A place lying immediately below a forest of pine or of other trees upon a mountain-side will be more sheltered against downward currents of cold air at night than will a place lying upon a bare and treeless hill-side. In the case of a valley running north and south, places lying upon its eastern slope will be warmer than those lying upon its western slope. When a range of mountains extends in a direction at right angles to the prevailing rain-bearing wind of a country, its leeward slope will enjoy a less rainy climate and a less clouded sky than will its windward slope.

So much by way of comment upon the variations existing in the type of a mountain climate. Let us now turn our attention to those general features which characterize the type. These are:

a. Diminished atmospheric density.
b. Reduction in temperature.
c. Relatively low *absolute* humidity.
d. Powerful insolation, both as respects heat and light.
e. Purity of air; *i.e.*, its great freedom from organic and inorganic dust, and from noxious gases ("aseptic air," Weber).

These five properties may be looked for in the climate of every elevated region, whether such region be of a strictly mountainous character or whether it be level in regard to the local configuration of the earth's surface—that is, of the nature of a plateau or table-land. The atmospheric density decreases as we ascend above sea-level in such proportion or ratio that, at a height of 2,500 feet, it is diminished by about twelve per cent.; at a height of 5,000 feet, by about sixteen per cent.; at a height of 7,500 feet, by about twenty-five per cent.

The diminution in temperature depending upon elevation amounts, in the temperate zone, to about one degree Fahrenheit for every three hundred feet of elevation.

The relatively low absolute humidity of the atmosphere found in elevated regions can hardly be said to be a characteristic of all mountain and plateau climates. It rather belongs to such regions as attain a very considerable degree of elevation above sea-level, such as the Davos and Upper Engadine valleys and the lofty plains, or Rocky Mountain foot-hills region of Colorado and New Mexico. In the two former mere elevation is doubtless the chief operative cause of a relatively low absolute humidity, by reason of the reduction it brings about in the temperature of the air. In Colorado and New Mexico the presence of a quickly drying soil and the absence of frequent rainfalls are unquestionably operative also; for on the Rocky Mountain plateau the *relative* humidity is low as well as the *absolute* humidity. At Davos and in the Upper Engadine the relative humidity does not appear to be especially low.

Mountain Climates.

That the sun's rays are more powerful at elevated stations than they are at places lying at or near sea-level seems to have been conclusively proved. With respect to the brilliancy of the sunlight, it may be said that it is probably greater throughout the year in mountain regions than on low-lying plains. The heat of the sun's rays appears to be greater at high-lying stations than at those of less elevation during the winter months; during the summer months some experiments by Volland seem to prove that the contrary condition of things exists—namely, that the lowland sun-temperature is higher than that of the highlands. (See article Gebirgsclima, in Eulenburg's "Real Encyclopädie," also, Dr. Weber's article on Climato-therapy, in Ziemssen's "Handbuch der allgemeinen Therapie.")* As indications of the increased lighting power of the sun's rays in elevated regions, Dr. Weber instances the superior distinctness and clearness of outline shown by photographs taken in such regions, and also the intensity of color found in such Alpine flowers as the gentian, forget-me-not, and campanula; the same varieties of grasses and of flowers, when found growing in the higher regions of the Alps, have an appearance, he tells us, which is quite different from that which characterizes them when growing at lower levels. The contrast between the shade- and sun-temperatures is far greater at elevated than at low-lying stations. Dr. Charles Denison, of Denver, Col., estimates the increase in the amount of this difference to be equal to one degree Fahrenheit for every two hundred and twenty-one feet of elevation ("The Influence of High Altitudes on the Progress of Phthisis," read at the International Medical Congress of 1876).

As to the purity of mountain air, its freedom from particles of organic and inorganic dust, and from noxious vapors—this valuable property, to which is largely due the health-restoring power of such air, is very greatly, if not chiefly, dependent upon the scantiness of population which is so generally characteristic of mountainous regions. At considerable elevations above sea-level in the temperate zones lowness of temperature doubtless plays an important part in freeing the atmosphere from all impurities caused by decomposing animal and vegetable bodies. In certain elevated regions the dryness of the air unquestionably operates to check or retard such decomposition. During the winter season at such "high-altitude" resorts as Davos and the Upper Engadine freedom of the air from dust is to a very considerable extent insured by the constant presence on the ground of a covering of snow. Pasteur found the air on the great glacier of the Mer de Glace vastly purer, as regarded its freedom from bacteria, than the air of the neighboring village of Chamounix; in fact, the glacier air proved to be quite free from bacteria, while the Chamounix air was full of them (Weber, *op. cit.*). The frequently cited experiments of Miquel showed 55,000 bacteria in ten cubic metres of air on the Rue de Rivoli in Paris, only 600 in an equal volume of air inside a hotel-room at Thun, only 21 in the out-of-door air at the same place, and none at all in the atmosphere of places lying in the Alps at an elevation of 2,000 metres (about 6,500 feet).

The immunity from pulmonary phthisis enjoyed by the native inhabitants of many elevated regions is no doubt largely due to this purity of the air; it is also in good degree a result of the out-of-door life and pastoral occupation of such inhabitants. At La Chaud de Fonds, a town lying in the Jura Mountains, at an elevation of some 3,000 feet, where watch-making is the principal industry, pulmonary phthisis is as prevalent and as fatal as it is in the low-lying city of Berlin. (See article Gebirgsclima, in Eulenburg's "Real Encyclopädie.") The danger of presuming upon the existence of pure air at any mountain resort, simply because it is a mountain resort, has been pointed out already in the remarks upon the risk of overcrowding contained in the article on Davos. The necessity of providing good drainage and good water-supply at such resorts has been but too well demonstrated in the outbreaks of typhoid fever at certain of our American mountain resorts, which outbreaks were traceable to a neglect of these sanitary precautions.

The presence of a large amount of ozone is said to be a leading characteristic of mountain as it is of sea air; it is also stated on good authority that positive electricity is more prevalent in the atmosphere of mountainous and other elevated regions than it is in that of lowlands.

With regard to the windiness of mountain climates, it is impossible to lay down any general rule of practical value. Elevation is probably accompanied by increased liability to exposure to wind, but in any mountainous region shelter from wind is a constant accompaniment of exposure; sometimes the one predominates, sometimes the other, according to the direction of the prevailing winds of the region, and according to the height and slope of the mountains themselves. The study of windiness as applied to mountain climates belongs in a pre-eminent degree to the special consideration of local climates; it is a part of the study of *climat de localité*, and such information as the reader desires on this point he must look for in the articles on individual health resorts. So much by way of consideration of the leading characteristics of mountain climates. We shall now proceed to discuss, briefly, the physiological and therapeutic effects of such climates.

In doing so it will be most convenient to separate the effects observed at places of considerable elevation (say from 4,000 to 6,000 feet and upward) from those which are characteristic of all mountain resorts, but which, when found alone and unaccompanied by the special effects of great elevation, may themselves be regarded as proper to, and especially characteristic of, the lower class of elevations. In studying the physiological and therapeutic effects produced by the climate of the more elevated class of mountain and plateau resorts, it is difficult to separate those which are due to mere diminution of atmospheric density from those due to the other modifications of climate found at great elevations, and there existing as accompaniments of, and in part necessary results of, this very diminution of atmospheric density. Respecting the physiological effects of lowered air-pressure we have already spoken briefly in the article on Health Resorts (vol. iii., p. 531). To the condensed statement there made we now purpose adding a few almost equally brief remarks upon the therapeutic and physiological action of "high-altitude climates," without attempting to discriminate between the parts played by atmospheric rarefaction, by low absolute humidity, by powerful insolation, and by the other associated factors of such climates, and taking pains to fight shy of the controversy which abounds regarding this complex, and, as yet, abstruse subject.

Circulation.—Resort to places lying 5,000 or 6,000 or more feet above sea-level produces at first an increase in the rapidity of the heart's action. The amount of this increase is usually not very great; as a rule it lasts only a few weeks (sometimes only a few days), after which time the pulse-rate is found to return to the normal. Dr. Weber thinks it *probable* that the force of the heart's action and the so-called "strength" of the pulse are increased by sojourn at elevated stations.

The circulation of blood in the vessels of the skin is improved by residence in the mountains, partly by reason of the lowered atmospheric density, partly by reason of the powerful insolation. It is probable that a similar effect is produced upon what we may, for the nonce, call the *inverted skin*—to wit, the mucous membrane of the respiratory tract. Upon this latter it is quite superfluous to say that powerful insolation can have no direct action; but lowered air-pressure will, of course, be operative here just as it is upon the rest of the air-exposed surface of the body, and a low absolute humidity will, in addition, be operative upon the pulmonary surface—for, by reason of the constantly high temperature of the interior

* A table on page 358 of vol. ii. of this HANDBOOK gives in parallel columns the sun-temperatures at one of the Swiss stations of medium altitude and at New York City, as observed during ten months of the year 1880. In this table an elevation of 3,175 feet is seen to be more than sufficient to counterbalance a difference of five and three-quarters degrees in latitude as regards the temperature of the sun's rays during the winter months. On the other hand, New York's sun-temperature from May to November seems to be higher than that of the Alpine station.

of the body, what is to the exposed skin a condition of mere *absolute* dryness in the atmosphere becomes to the lungs a condition of potential dryness, of a dryness having power to accelerate evaporation from a moist surface. This condition of things holds good, to be sure, only in case the shade-temperature of the air be considerably below that of the blood (98.4° F.); but in all "high-altitude" resorts of the temperate zone, and in mountains of great elevation even in the tropics, the temperature is, with rare exceptions, quite low enough to allow of this special action of low absolute humidity upon the surface of the pulmonary lining. The colder the external air the greater is the contrast between the effect of a low degree of absolute atmospheric humidity upon the skin and upon the lungs respectively.

Already, in the general article on Climate and in the special article on Davos, reference has been made to the comparative values of absolute and of relative humidity as climatic factors; but, while adhering to the opinion of Dr. Julius Hann, that the latter is the better and more valuable index of the two when we regard climate from the physiological and therapeutic point of view, the writer nevertheless appreciates the plausibility of what has been said by Dr. Steffen, Dr. Weber, and others regarding the special action of *combined low atmospheric temperature and low "absolute" humidity* upon the *pulmonary* surface. Although the inspired air tarries but a short time within the respiratory cavity, and although it is probable that when it is very cold such brief sojourn within that cavity will not be adequate to raise its temperature up to the blood-heat, nevertheless this brief sojourn will suffice to elevate its temperature very considerably; so that the *relative* humidity of the air within the respiratory cavity under such conditions will doubtless be diminished, just as happens to cold air of low absolute humidity when admitted to the interior of an artificially heated apartment. Thus it is that, with a condition of low atmospheric temperature, the inside skin, the respiratory mucous membrane, may be exposed to air of low relative humidity when the outside skin is not thus exposed. After all, it will be observed that in each case relative humidity, rather than absolute humidity, is the index to the physiological action of the atmosphere considered as to its dampness. The former is a measure of the moisture-absorbing power, of the "Evaporationskraft," of the air; the latter, *when considered apart from the factor of atmospheric temperature,* is not such a measure. So far as the lungs alone are concerned, absolute humidity is probably a weightier factor in climato-dynamics than is relative humidity.

Respiration.—According to Dr. Weber, the increase in the frequency of the respirations observed in persons resorting to elevations of from 4,000 to 8,000 feet lasts only a comparatively short time, and is inconsiderable in amount (two to five respirations per minute). In thirty healthy, or nearly healthy, persons who had passed from two to twenty weeks at elevated stations, a large number of examinations showed no alteration in respiratory frequency as a result of eighty-two per cent. of the examinations, a decreased rapidity of respiration in six per cent., and an increased frequency (two to four respirations per minute) in twelve per cent. The question as to whether the volume of air taken into and expired from the lungs with each respiratory act be or be not increased by sojourn at elevated stations is as yet in controversy. That the diminution in atmospheric density found in all high-lying regions occasions any reduction in the supply of oxygen below a point sufficient to satisfy the demands of the human organism is unlikely, at least in the case of elevations amounting to less than 6,500 feet. Above that point it is possible that the so-called "oxygen hunger" may manifest itself. Jourdanet claims that it does so. Dr. Yeo thinks that the diminution in the amount of oxygen caused by the rarefaction of mountain air is in good degree compensated by the relative coldness of such air, which coldness would tend to increase the amount of oxygen. This, he thinks, holds good especially in the case of glacier air, and he draws a parallel between the body of air overlying a glacier and an inverted can of milk; in a can of milk the cream accumulates at the top, in glacier air its cream, the oxygen, accumulates at the bottom.

An increase in the circumference of the chest has been frequently observed to follow protracted residence in regions of considerable elevation. Such increase, according to Drs. Boner and Weber, is due to the extra work thrown upon the inspiratory muscles by reason of the lessened resistance opposed by the rarefied air to the contracting force of the pulmonary elastic tissue. Large girth of chest has been observed to be a characteristic of inhabitants of elevated regions. In fourteen cases where poorly developed chest existed in young persons not yet affected with pulmonary disease, Dr. Weber found a residence of from three to twelve months at a considerable elevation above sea-level to be followed by an increase of chest-girth amounting to from one to two and a half centimetres.

Assimilation, etc.—At elevations of less than 6,500 feet healthy persons experience an increase in their appetite for food. The same is true of most invalids who retain a moderate amount of energy. Some of the feebler class of invalids, especially such as habitually have more appetite in warm than in cold weather, experience a diminution in the desire for food on first going to the mountains, even when the elevation attained does not exceed 4,000 or 5,000 feet. This loss of appetite may be but temporary; it may sometimes persist, and compel a return to lower-lying regions. An improvement in the general nutrition of the body, and in the quality of the blood, is usually produced by sojourn in the mountains, and nervous and muscular energy are increased. As to sleep, there is no absolute rule—some persons sleep better and longer; some sleep less long, but perhaps more restfully; some sleep less well in elevated regions than at sea-level or at places of insignificant elevation above sea-level (Weber).

Climato-therapy.—In discussing the therapy of mountain resorts it will be most convenient to divide such resorts into a higher and a lower class, and to consider each class separately. Following the plan adopted by Dr. Weber, we shall speak of contra-indications before setting forth the pathological indications for treatment at each of the two classes.

"*High Altitudes.*"—The conditions contra-indicating resort to the higher-lying mountain and plateau stations are: Organic disease of the heart, especially when accompanied by decided disturbance of the systemic or pulmonary circulation; arterial atheroma, whether due to senility or premature senility; Bright's disease; asthma, when accompanied by cardiac disease, emphysema, and bronchiectasis; chronic bronchial catarrh with emphysema and bronchiectasis; advanced and still progressing pulmonary phthisis; tendency to pulmonary hæmorrhages, *when cavities exist in the lungs;* diarrhœa, when due to tubercular ulceration of the intestines; tubercular laryngitis; complication of pulmonary phthisis with especially severe dyspeptic symptoms; epilepsy, hysteria, and organic nervous disease; gout and rheumatism; the possession of the so-called "erethitic" constitution—that is, of an especially marked tendency to elevation of temperature and acceleration of pulse, with any disturbance of the health. Very young children are not well adapted to residence at the "high-altitude" stations of Europe, but in our warmer Colorado and New Mexico resorts they would probably do better. In "high-altitude" resorts, just as in the lower-lying pulmonary sanatoria, the prognosis is not good in patients possessing a marked hereditary tendency to consumption. Those who are too feeble to take any out-of-door exercise, or who have an exceptionally feeble power of resistance to cold and to changes of temperature, are hardly proper persons to be sent to the higher-lying stations, at least of the temperate zone. Senile atheroma has already been specified as a contra-indication of "high altitudes;" senility, without positive evidence of this arterial change, may be added to this list, for other reasons which demand no detailed explanation in this place.

We have now presented a pretty long list of conditions likely to render recourse to the higher-lying health sta-

tions either positively risky, or, at least, not especially advisable, having taken our data from the works of various authorities on this subject, and having endeavored to avoid any important omission. That equal weight is not to be attached to all these contra-indications alike will be manifest to any careful reader. The sum-total of these pathological states and symptoms may be regarded as the entire mass of clinical evidence against "high-altitude" resorts; and, while none of them should be forgotten, it is nevertheless true that the element of *degree* should be constantly borne in mind by the physician who, when called upon to give advice to a patient in the selection of a health resort, finds one or more of these contra-indicating conditions present, inasmuch as the existence in a slight degree of one or more of these vetoing factors should not counterbalance positive and strong indications for the "high-altitude" treatment possessed by the patient who is seeking his counsel.

Let us now turn our attention to a consideration of the advantages of "high altitudes." We shall find that these are beyond question very considerable, and that for the amelioration or cure of pulmonary phthisis, in particular, resorts of this kind are quite equal to, and perhaps superior to, any others.

It is especially in the early stage of consumption that these high-lying resorts are found to be beneficial, and it is probable that in cases but little advanced in this disease a larger percentage of cures has been hitherto obtained at "high-altitude" resorts than at health stations of comparatively low elevation. The purity of the air and its power to exercise both a cooling and a drying influence upon the diseased pulmonary surface are no doubt largely to be credited for this favorable result. The improvement in the nutrition of the lungs, which has been referred to already, is another important factor in checking the morbid process; while the general tonic influence exerted by the climate of elevated regions upon properly selected cases, the increased appetite, hardening of the skin, etc., are none of them to be lost sight of in studying the healing influence of "high-altitude" climates upon this formidable disease. In Dr. Weber's article on climatotherapy (in Ziemssen's "Handbuch der allgemeinen Therapie") the reader will find stated in detail the beneficial effects exerted by "high-altitude" climates upon each one of the common symptoms and complications of pulmonary phthisis. Suffice it to say in this place that the presence of hæmoptysis, except under the conditions specified in the section on contra-indications, does not exclude a case from the category of such as are ameliorable or curable by "high-altitude" treatment. On the contrary, it has been observed that pulmonary hæmorrhages occur less frequently at elevated than at low-lying stations. For example, at Davos Dr. Ruedi finds that "cases of hæmorrhagic phthisis, where the hæmorrhages are profuse and the physical signs slight," do very well.*

As an example of the results of "high-altitude" treatment in consumption, we refer to the personal experience related by Dr. Weber (*op. cit.*). Benefit derivable from "high-altitude" treatment is not to be looked for in pulmonary phthisis alone, but may be also expected in certain cases of chronic pleuritic exudation and of unresolved pneumonia. In certain cases of anæmia, from malarial poisoning or from other causes, and for persons of vigorous constitution suffering from the effects of mental overwork, the higher-lying mountain stations are also often beneficial; although for this class of indisposition, or ailment, the lower-lying mountain resorts are usually quite as good. The duration of the "high-altitude" treatment should vary in different cases, but it is a mistake to suppose that permanent residence in such a climate is necessary to secure permanency of the good result which is often obtained in cases of phthisis. On the contrary, "high altitudes," when compared with warm, low-lying winter resorts, are more likely so to restore the patient to health that this restoration will prove abiding and such as to qualify him for resuming residence at his own home, wherever that may be situated. In resorting to places of great elevation the invalid should, as a rule, break the journey at one or more halting-places of intermediate elevation. This is especially advisable where the presence of any contra-indicating symptoms or lesions renders the result of "high-altitude" treatment more or less questionable. On returning from higher- to lower-lying regions, it is equally, perhaps even more important to do so gradually and by easy stages. Concerning the proper season for the "high-altitude" treatment, it may be said that this varies with the disease and with the particular resort chosen; for a determination of this point the reader must be referred to the articles on individual health resorts.

Lower-lying Mountain Resorts.—For the most part, resorts of this class are only suitable for summer residence, not being high enough to enjoy the powerful insolation and marked dryness of the air which characterize so many of the higher mountain stations during the winter season. The purity of the air is less marked than at higher levels, but, owing chiefly to the sparseness of the population, is nevertheless greater than it is on the plains; not greater than at the sea-side. The contrast between the day and night temperatures is marked, and the dewfall is apt to be heavy. There is much ozone in the atmosphere. The air is apt to be filled with the aromatic, refreshing, and health-giving exhalations from the trees of the forests which usually clothe the mountain-sides, and its more complete saturation with these exhalations is insured by that crowding together of much woodland within a limited area which results from the configuration of the ground. Dr. J. Burney Yeo, in his valuable work, entitled "Climate and Health Resorts," has pointed out the great similarity existing between the climates of mountain regions and of the sea-side respectively, and the error of those who regard them as opposite, or, so to say, antipodal one to the other. Both are tonic or fortifying; but while the sea-side exercises usually a soothing as well as a fortifying action upon the invalid, the mountains are exciting or stimulating as well as tonic in their climatic effect. Hence, for elderly persons who, in the mountains, are frequently tempted by the tonic action of the air to over-exertion, the sea-side is apt to be a safer and a more beneficial place of resort. The possible risk attending a visit to places of even very moderate elevation above sea-level, in cases of cardiac disease (whether known or unsuspected), has been alluded to in the article on Health Resorts (see vol. iii., p. 533, right-hand column, near top). For pulmonary cases many mountain resorts of moderate elevation will be found useful as summer sanatoria; but there is quite as much, and perhaps even more, need for care in guarding against changes of temperature at this season in these lower hill-stations as there is during winter at the resorts of the "high-altitude" class. Children generally do better at the sea-side than they do in the mountains.

Among conditions indicating the advisability of a summer trip to the mountains may be mentioned a tendency to, or convalescence from, malarial fever (although it is not every mountain resort where exemption from malarial poisoning may be expected); many cases of hay-fever and of uncomplicated asthma; exhaustion from brain overwork in persons possessing a naturally strong constitution both physically and mentally, and a condition of anæmia and general exhaustion brought on by long-continued summer heat, especially among dwellers in large cities or in those who live near the sea-coast.

Huntington Richards.

MOUNT CLEMENS MINERAL SPRING. *Location and Post-office*, Mount Clemens, Macomb County, Mich.

Access.—From Detroit by the Grand Trunk Railway, or by steamer leaving daily.

Therapeutic Properties. — Besides an extremely large proportion of sodium chloride, this water contains other valuable ingredients which render its use as a bath or beverage exceedingly useful in the treatment of chronic skin affections, rheumatism, and gout. Thorough pro-

* See "The High-Altitude Treatment of Phthisis," an excellent series of articles by a special correspondent of the London Lancet, in the numbers of that journal for January 8, February 12, and March 12, 1887.

vision is made for the proper and comfortable treatment of patients.

ANALYSIS.—One pint contains (temperature 56° F.):

Solids.	Grains.
Carbonate of magnesium	trace
Carbonate of lime	0.497
Chloride of sodium	1079.680
Chloride of magnesium	16.200
Chloride of calcium	21.552
Sulphate of soda	9.656
Sulphate of lime	4.400
Sulphide of iron	trace
Iodine	0.040
Silica and alumina	trace
Ammonia	trace
Potassium salts	trace
Total	1132.025
Gases.	Cub. in.
Carbonic acid	trace
Sulphuretted hydrogen	3.044

Mount Clemens is situated about twenty miles north from Detroit, on the Clinton River, which empties into Lake St. Clair five miles east of the city. It (Mount Clemens) has a population of about four thousand. The surrounding country is attractive, with good roads for drives, and fishing is found at the mouth of Clinton River. About 1870 a company was formed to manufacture salt from brine pumped from a well twelve hundred and forty-four feet deep. The cure of a foundered horse, effected by standing in the mud formed by drippings from the tanks, caused a resident afflicted with scrofulous troubles to try bathing in the water. His restoration to health was the origin of this spring as a health-resort, and it has continued to increase in popular favor. There are several good hotels and a commodious bath-house.

George B. Fowler.

MOUSSENA (*Boussena*, Codex Med.). The bark of *Acacia anthelminthica* A. Rich. (*Albizzia anthelminthica* Ad. Br.). A good-sized shrub of the warmer parts of Abyssinia. It is said to be an efficient tænicide, "more certain than koosso, acting without purging, nauseating, or producing colic." It is not in our market.

ALLIED PLANTS.—See SENNA.

ALLIED DRUGS.—See KOOSSO. *W. P. Bolles.*

MUCOID DEGENERATION (*μύξα*, mucus; *εἶδος*, like).

SYNONYMS.—Mucous degeneration, mucoid or mucous metamorphosis or softening.

DEFINITION.—The term mucoid degeneration is applied to the morbid process by which various tissues of the body, or of neoplastic growths or exudations, are converted into a clear, homogeneous substance containing mucin.

DESCRIPTION.—Mucin is normally present in the vitreous humor of the eye, in the Whartonian jelly of the umbilical cord, in the subcutaneous and inter-muscular tissues of the fœtus; and, in solution, is the characteristic element of the secretions of the various mucous membranes, giving them their tenacious character. From these fluids it may be precipitated by the addition of acetic or mineral acids, alum, or alcohol. Acetic acid produces delicately fibrillated masses, which swell up but do not dissolve in water, yet are readily soluble in an excess of a mineral acid. It is distinguished from the albuminates by a relatively less proportion of carbon and nitrogen, and by the absence of sulphur.

In the mucous secretions mucin is the product of a metamorphosis occurring in epithelial cells. These may be gland-cells, as those of the muciparous follicles of the bronchial mucous membrane, or they may lie superficially, as the goblet-cells found in the mucous lining of the gastro-intestinal tract.

Mucin is closely related, in chemical composition as well as in microscopical appearance, to the product of the colloid or vitreous degeneration; the latter has, however, a different chemical composition, and reacts differently to acids and alcohol.

The cell that is undergoing the mucoid metamorphosis swells up, owing to the formation within it of one or more large transparent molecules, which also displace the nucleus and crowd the granular protoplasm of the cell to the periphery, or into little groups or bands. The entire cell may thus become converted into a glassy globule, involving the destruction of the nucleus. It may then rupture, give exit to the contained mucin, and, according to some authors, recover; according to Heidenhain, however, the evacuation of the mucin involves the death of the cell. The so-called mucus-corpuscles are leucocytes which have undergone the mucoid transformation. Whether the mucin found in the vitreous humor and in the Whartonian jelly is a result of this metamorphosis affecting cells or fibres, is not known. Its presence in the subcutaneous and intermuscular tissues of the fœtus is equally difficult of explanation.

The morbid process involved in the mucoid degeneration is identical with that which has just been described, and may occur in either a cellular or a fibrous structure. It is often intimately associated with the fatty metamorphosis, and in some instances is confined to the intercellular tissue, while the fatty degeneration occurs within the cells.

Mucoid degeneration finds its closest analogy to the physiological production of mucus in the case of a catarrhal inflammation of a mucous membrane. Here the increased secretion of mucus is due to a rapid metamorphosis of epithelial elements, which, with the aid of the microscope, may be discovered in the secretion in every stage of the process. The gland-cells are often converted into translucent globules, and in membranes lined by columnar epithelium, the goblet-cells become vastly more numerous than they are during physiological activity. This rapid destruction of cells implies a rapid new-formation which is supported by a hyperæmic condition that is always present.

A cystic softening, due to mucoid degeneration, frequently attacks cartilaginous structures, particularly the costal cartilages, the inter-vertebral disks, and other inter-articular plates in old persons. A similar degeneration frequently accompanies acute and chronic inflammations of joints, and to it in part is due the softening of bone in osteo-malacia and in the vicinity of neoplasms.

The medulla of bones and the subcutaneous fat are liable to degeneration, in consequence of atrophic changes.

The cellular elements and stroma of neoplasms are also subject to mucoid degeneration. Probably the best example of this is found in the myxomata. These tumors all contain a variable amount of fibrous or reticular connective tissue and a peculiar type of cells, from which the mucin is supposed to be derived, and they are classed by some authors with the fibromata or lipomata. The more compact fibromata may become in part mucoid, losing their firmness and assuming a cystic character. A similar course of softening and final disintegration, more or less complete, is of frequent occurrence also in lipomatous tumors.

The sarcomata are especially prone to undergo this transformation, the degeneration affecting either the cellular elements or the stroma. The tumor thus degenerated is designated a myxo-sarcoma.

Clear globules of mucin are sometimes encountered in the cells of cancers, especially in those springing from the mucous membranes or from the ovaries. When the degeneration is excessive, affecting both stroma and cells the tumor assumes a translucent, gelatinous texture, and receives the name myxomatous carcinoma, or carcinoma myxomatodes. This species of tumor is less liable to mucoid degeneration than the sarcoma.

The cells of adenomata often become mucoid; typical goblet-cells are sometimes found among the epithelial cells lining ovarian and intestinal cysts. The colloid degeneration also may give this appearance. The intercellular substance of the enchondromata is sometimes softened in the same manner.

Finally, it is in part by a mucoid metamorphosis that blood-exudations and extravasations, the exudations of croupous and catarrhal pneumonias, and the fibrinous exudations on the surfaces of serous membranes in a state of inflammation, as in pleurisy and peritonitis, are prepared for absorption. *James M. French.*

MULBERRY JUICE (*Mori Succus*, Br. Ph.; *Mure*, Codex Med.). The juice of the Black Mulberry, *Morus nigra* Linn. Order *Urticaceæ*. Several species of Mulberry are in cultivation, generally as food for silk-worms, which devour the leaves. The above, with a dark blackberry-like cluster of pleasantly acidulous drupes, originally probably from Western Asia, is more valued for its fruit than leaves, since the White Mulberry, *Morus alba* Linn., with larger, sweeter, pale yellow fruits, was introduced from China, and has largely taken its place in silk-worm raising. Our North American Mulberry, *M. rubra*, with dark reddish-brown fruits of mawkish taste, resembles the first named. All are small trees with heart-shaped, more or less rough or downy, astringent leaves, and bitter, disagreeable-tasting purgative barks. The latter have been used as tænicides. Mulberry juice has a dark violet or purple color, a faint odor, and a refreshing, sweetish-sour taste. A syrup is official both in England and France. *Grape-sugar*, *Malic*, and probably other *fruit acids*, are its important constituents. It is employed as a refrigerant, and as a vehicle in preparing gargles. The great use of milk in fevers, etc., makes the sour vegetable drinks less available than they used to be.

Allied Plants.—*M. tinctoria* is used as a dye; for the order see Hemp.

Allied Drugs.—Elder Berries, Barberries, Tamarinds, and other fruits. *W. P. Bolles.*

MULLEIN (*Bouillon blanc ou Molène*, Codex Med.). *Verbascum Thapsus* Linn.; Order, *Scrophulariaceæ*. The common woolly Mullein of Europe and this country is familiar to everyone. Both leaves and flowers are regarded as of medical utility, and are collected for the market.

The Mullein of the German Pharmacopœia (*Flores Verbasci*) consists, according to that authority, of the flowers of *Verbascum phlomoides* Linn., and of *V. thapsiforme* Schrod. The flowers are all much alike in appearance and properties, and rather indiscriminately gathered. Mullein is but little used in this country. In Europe it appears to be more called for. It is devoid of active qualities, and makes a mild tea which can be drunk freely in bronchial catarrh, etc., if desired.

Allied Plants.—See Foxglove. *W. P. Bolles.*

MUMPS. Synonyms.—Cynanche parotidæa; parotitis; parotiditis; Fr., *Oreillon*; Ger., *Ziegenpeter*.

Mumps is an acute, specific, infectious disease, self-limited, characterized by inflammation of the parotid, and sometimes of the submaxillary and sublingual glands, with a tendency to migrate into the mammæ or testes, and almost invariably ending in recovery.

Nature and Etiology.—Mumps prevails widely as an epidemic, and also occurs in the sporadic form.

It is propagated by a peculiar virus the nature of which is unknown. The disease is communicated by contact with the infected, and by the intermediation of various substances to which the virus adheres. The contagious principle is supposed to be chiefly transmitted by the breath, and is capable of reproducing the disease from the beginning of the parotid swelling up to ten days or two weeks after the fever has subsided. It is highly contagious. When the disease breaks out in schools, children's hospitals, or other institutions where large numbers of young people are congregated, few escape, unless protected by a previous attack. However, the susceptibility is not the same in all individuals.

It is quite rare in infancy and after the middle period of life, occurring chiefly in youth and early manhood. Males are more prone to attack than females. Like the other diseases of the class to which it belongs, it rarely occurs more than once in the same individual.

It is more apt to prevail during the winter and spring, but epidemics have been observed at all seasons. Bad hygienic surroundings very certainly favor its diffusion.

The period of incubation varies greatly, and is estimated by different authors at from ten to twenty days.

Morbid Anatomy.—The opportunity for post-mortem examination in cases of mumps, for obvious reasons, is very limited. On this account pathologists differ as to the seat of the morbid process; some locating it in the gland proper, and others in the peri-glandular connective tissue. Among those who maintain the glandular origin, some hold that it is rather the fibrous stroma which supports the acini than the acini themselves, which are primarily involved.

The weight of authority is, perhaps, in favor of the initial lesion being a catarrhal inflammation of the gland-ducts, but the local swelling which gives character to the disease is unquestionably largely due to an infiltration of the surrounding cellular tissue. The swelling disappears by the absorption of the exudation, and only in very exceptional instances is there any tendency to suppuration.

Occasionally the glands remain enlarged for a considerable time, and, in very rare instances, the enlargement and hardening are permanent. Atrophy of the parotid has also been observed as a result of an attack of mumps.

Symptoms.—Premonitory symptoms are, in most instances, either absent, or so mild as to attract little attention. When present they are those most commonly met with in mild febrile attacks: Chilliness, hot flushes, languor, anorexia, and sometimes vomiting and diarrhœa.

Very exceptionally the initial symptoms assume a grave character, and the disease is ushered in with high fever, profound depression, persistent vomiting, and, in children so predisposed, with convulsions.

Pain and tenderness in the region of one or both parotid glands, if not present from the beginning of the illness, very soon make their appearance, and are never delayed longer than twenty-four or thirty-six hours. Swelling appears simultaneously with the pain and tenderness. It is at first noticed in the depression between the mastoid process and the ramus of the jaw, and is confined to the gland. However, the adjacent cellular tissue is soon invaded, and the tumefaction extends forward on the face and downward and backward on the neck.

The degree of enlargement varies greatly, being at times moderate and confined to the parotid region, and in other cases involving a large portion of the face and neck. When both parotids are involved and the swelling is fully developed the configuration of the face is peculiarly altered, the lower half of the face being enormously widened and the outline of the chin lost in the œdema of the neck. The swelling is firm, slightly elastic, and moderately sensitive to pressure. The head is fixed with the face directed straight forward, or, if but one parotid is affected, the head will be inclined to the diseased side. The skin usually preserves its natural color, but may be red and glossy. Slight desquamation may take place after the inflammation has subsided.

More or less fever is always present, lasting, in cases of moderate severity, not more than four or five days, but occasionally it is intense and protracted.

The œdema generally extends internally, affecting to a greater or less degree the mucous membrane of the tonsils and pharynx. The secretion of saliva may not be materially altered in quantity, but dribbles continuously from the half-open mouth.

Earache, or a constant ringing in the ears, is often experienced, and the hearing is temporarily impaired, and, in very rare cases, permanent deafness may follow. The movements of the jaw are, of necessity, greatly impeded and very painful. Speech is difficult, and the voice is husky or muffled.

Mastication and deglutition are almost entirely suspended, the patient enduring the pangs of hunger rather than undergo the suffering required to satisfy his wants.

Mumps usually affects both parotids, but not simultaneously; the left is most frequently the first to become involved, and in from two to four days afterward, or even when the swelling has disappeared, the opposite gland becomes the seat of disease. Not infrequently the affection is limited to one side.

Very often the submaxillary and sublingual glands are affected conjointly with the parotids. Dr. Penzoldt, of Erlangen, records an epidemic of mumps which fell under his observation, in which there were many cases

where the diseased process was almost wholly confined to the submaxillary glands.

The swelling reaches its height in from two to five days, remains stationary about forty-eight hours, and then rapidly subsides, making the duration of the attack from ten to fourteen days.

A very singular and inexplicable feature of mumps is the tendency for other organs to become involved by so-called *metastasis*. The testes in males and the mammæ in females are the glands of special election. This metastasis is much commoner in males than in females, and less common in childhood than in adult life. When the testicle is invaded, it becomes swollen and painful, and there is often effusion into the tunica vaginalis, with œdema of the scrotum. Bruising of the testes is said to invite the disease.

The migration may take place at any period of the parotid swelling, which then usually subsides, but occasionally the two inflammations run their course together. Sometimes the inflammation of the parotid disappears suddenly before the advent of the metastatic affection; in this event, alarming constitutional symptoms are liable to supervene. There may be high fever, headache, delirium, or profound collapse, which promptly disappear on the appearance of the local lesion. The new affection runs a course very similar to that of the original disease, and lasts about the same length of time.

Prognosis.—Mumps is a mild though painful disease, and almost invariably runs a favorable course. The inflammation of the parotid rarely leads to the formation of an abscess, contrasting, in this respect, strongly with the non-specific form of parotiditis which occurs in the course of typhoid fever and other maladies.

Occasionally a hard, painless enlargement of the gland is left, which persists for a variable time and disappears, but which, in very exceptional instances, may be permanent.

Atrophy of the testicles sometimes results from the metastatic orchitis, or their function may become impaired from occlusion of the spermatic duct.

The Diagnosis is rarely attended with difficulty. It can scarcely be mistaken for any affection other than the non-specific inflammations of the parotid glands, which occur as complications of various constitutional diseases.

The comparative mildness of the general symptoms, the speedy resolution of the swelling, and the epidemic character of mumps, contrast strongly with the preceding severe illness and the inherent tendency to suppuration which constitute the clinical features of the non-specific or symptomatic parotiditis.

Treatment.—The treatment is purely symptomatic. The disease is self-limited and runs a definite course, uninfluenced by the administration of drugs.

The patient must remain in-doors, preferably in bed, even in mild cases, until convalescence is assured.

On account of the difficulty in swallowing, the diet should be exclusively fluid. If there should be high fever, a bath or surface sponging with tepid water will be of service. Should there be much pain or restlessness, an anodyne, preferably Dover's powder or chloral, may be prescribed; otherwise refrigerant diaphoretics, such as a solution of bitartrate or citrate of potash, or the neutral mixture of the Pharmacopœia, will meet all of the indications. External fomentations to the neck are both useful and grateful to the patient. Soap liniment, to which a little deodorized tincture of opium may be added, warm olive-oil, or the tincture of belladonna and glycerine (℥ j. to ℥ j.), are eligible preparations for external use.

When metastasis to the testes or other glands takes place, the new affection should be treated in the same manner as if it had occurred independently of the parotid inflammation. If the onset of the metastasis is heralded by great prostration, or alarming symptoms of any kind, stimulants must be freely given and warmth applied to the body.

A course of tonics is advisable should convalescence be tardy.

W. J. Conklin.

MUSCLES, ANOMALIES OF. The muscular system of man is subject to many variations, all of which are interesting from a morphological point of view, and many are important surgically. Not only do muscles vary as to form and attachment, but supernumerary and rudimentary muscles are not infrequent. Again, some may be absent in a certain number of individuals; *e.g.*, the pyramidalis, palmaris longus, etc.

Many muscles are mere rudiments of those which exist in a well-developed condition in the lower animals, and there is, in fact, no muscular variation in man which has not a corresponding normal condition in some animal lower in the scale.

In the present article space forbids the giving of any extended account of muscular variations, for it is a subject on which volumes have been written. It is only intended to describe the commoner and more important anomalies, especially mentioning those whose relation to arteries renders them of surgical interest. The reader who wishes to obtain a fuller knowledge of the subject is referred to Wood, Turner, and others, in the *Journal of Anatomy and Physiology;* J. Wood, "Proceedings of the Royal Society," 1864–69; "Guy's Hospital Reports;" "St. Thomas' Hospital Reports;" Macalister's "Catalogue of Muscular Anomalies," in "Trans. Royal Irish Academy," 1872; W. Gruber, in the *Mem. of Acad.*, St. Petersburg, and Virchow's *Archiv f. Klin. Med.;* Henle, "Handbuch, Muskellehre;" Hallett, *Edin. Med. Jour.*, 1845; Krause, "Handbuch," 1880; Testut, "Les Anomalies Musculaires chez l'Homme," Paris, 1884; also various papers in the *Journal of Anatomy and Physiology.*

Muscles of the Head and Neck.—*Occipito Frontalis* varies much as to size and position. The *occipitalis* occasionally approaches the median line, and may be divided into several portions. Some of its fibres may be continuous with the posterior auricular muscle.

The *Frontalis* may send slips to the nasal and superior maxillary bones. Theile says that it generally sends a bundle of fibres to the external angular process of the frontal bone. Its fibres have been described as normally continuous with the levator labii superioris alæque nasi.

Auricular Muscles.—Very various as to their development. The retrahens is very often of large size, and its tendon frequently arises from the neighborhood of the external occipital protuberance; in such cases its belly is very fleshy, and may be divided into two portions. It is sometimes connected with the transversus nuchæ. Cruveilhier has described a deep *musculus auricularis anticus*, which goes beneath the superior from the zygoma to the outer surface of the tragus. The anterior auricular muscle is often very much diminished in size, and its fibres may be very indistinct.

Muscles of the Nose.—Absence of the pyramidalis has been observed. The compressors and dilators are often so feebly developed as to be seen only with a magnifying-glass.

The *Musculus Anomalus* (Albinus) is a slip described as being frequently present. Lying beneath the levator labii superioris alæque nasi, and arising with it from the nasal process of the superior maxillary bone, it is inserted into the same bone near the origin of the compressor naris.

Muscles of the Face.—Zygomaticus Major. Frequently double. The second head may arise in the neighborhood of the infra-orbital foramen or from the masseteric fascia below the zygoma. It is sometimes absent.

Zygomaticus Minor. Frequently absent. It may be inserted into the fascia of the cheek. It may be fused with the levator labii superioris proprius, zygomaticus major, or frontalis. It is not infrequently double; the second head may arise in common with the levator labii superioris proprius. Sometimes it arises from the orbicularis palpebrarum, and it may be inserted into the levator labii superioris proprius or levator labii superioris alæque nasi, or both.

Levator Labii Superioris Proprius occasionally sends a slip to the zygomaticus minor. The writer has twice seen this muscle arise by two heads, the extra head arising from the malar bone. In both these cases the zygomaticus minor was present.

Risorius (Santorini). Often absent. Santorini describes it as double, and even triple. It has been seen to arise from the zygoma, external ear, fascia over the mastoid process, and the skin over the upper portion of the sterno-mastoid.

Depressor Anguli Oris (triangularis menti). Santorini described a muscle, the *transversus menti*, which is sometimes found arising from the inner border of the depressor, and passing downward and inward across the mesial line below the chin to the corresponding part of the opposite side.

Muscles of the Orbit.—Levator Palpebræ. Sometimes absent or fused with the superior rectus. Budge describes the *tensor trochleæ*, which is a muscular slip given off from the levator to the trochlea.

The muscles of the eyeball are very constant. The two heads of the *rectus externus* have been seen separate to their insertion, forming a double muscle. Absence of the outer head has been noted by Macalister, and Curnow describes it as giving slips to the outer wall of the orbit and lower eyelid.

Transversus Orbitæ (Bochdalek). This is an arched slip of muscular fibres passing from the orbital plate of the ethmoid across the upper surface of the eyeball to the outer wall of the orbit (Quain). Macalister suggests

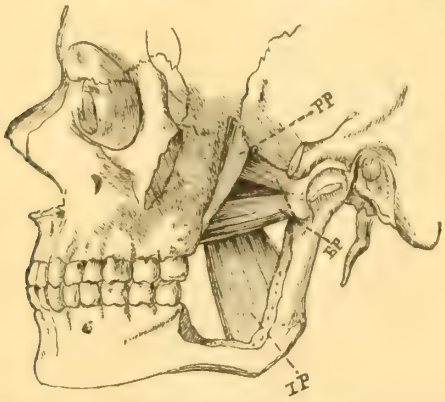

FIG. 2352.—*PP*, pterygoideus proprius; *EP*, external, and *IP*, internal pterygoid muscle. (Shepherd.)

that it is a deep, displaced slip of the palpebral fibres of the orbicularis.

Muscles of Mastication.—Masseter. Monro has described a bursa as occasionally occurring between the two portions of this muscle, and Hyrtl has once seen a bursa between the masseter and the capsule of the inferior maxillary articulation.

Temporal. Henke says that sometimes the temporal muscle, and sometimes the deep portion of the masseter, is attached to the fore and back part of the interarticular fibro-cartilages of the lower jaw, or from these borders muscular fibres arise which are inserted into one or other of the afore-mentioned muscles. In many cases these fibres form a well-developed muscular belly, the *musculus temporalis minor*, which is inserted into the bottom of the sigmoid notch of the lower jaw (Henle). The writer has occasionally seen a deep slip from the temporal muscle attached to the pterygo-maxillary ligament. This slip is sometimes pierced by the internal maxillary artery.

Pterygoideus Externus. A considerable portion may be inserted into the capsule of the inferior maxillary articulation. When the pterygoideus proprius is present the upper head is of small size.

Pterygoideus Proprius. This is a muscle which is not infrequently seen arising from the infra-temporal crest of the sphenoid and part of the great wing itself; it then passes over the external pterygoid to the lower part of the external pterygoid plate, or to the tuberosity of the palate and superior maxillary bones. It sometimes receives a slip from the upper head of the external pterygoid, and a portion of the upper head of the muscle may arise from it. The writer has occasionally seen the pterygoideus proprius inserted into the pterygo-maxillary ligament and alveolar process of the upper jaw (see Fig. 2352). In one case it sent a slip over the internal pterygoid to be inserted into the inferior maxilla near its angle. Externally this muscle is tendinous, and deep down, muscular; sometimes it is tendinous along the inner border only. When the pterygoideus proprius is present, the upper head of the external pterygoid is generally much diminished.

Pterygo-spinosus (Thane). This name is given to a muscular slip occasionally seen springing from the spine of the sphenoid and inserted into the hinder margin of the outer pterygoid plate, between the external and internal pterygoid muscles; the parts are frequently connected by fibrous tissue, and sometimes by bone.

MUSCLES OF THE NECK.—*Platysma Myoides.* This muscle varies considerably in its development. It is sometimes well developed, thick and red, and at other times its fibres are pale, thin, and hardly to be seen. It has been reported absent by Macalister. The platysma may reach over the clavicle as far as the fourth rib. It sometimes fails to reach as far as the clavicle: in such cases it is reduced in extent at other parts as well. It may have an insertion into the thyroid cartilage or the sternum. When well developed it has been seen attached to the lower jaw above and to the clavicle below. The upper part of the platysma is occasionally joined by a slip from the mastoid process, or from the occipital bone. The two muscles not infrequently cross each other in the median line. The writer has seen the lower fibres continuous with some fibres of the musculus sternalis. Fasciculi in connection with this muscle have been traced to the axilla. The platysma is the principal representative in man of the skin muscle (*panniculus carnosus*) of the lower animals. In most mammals with loose skins these tegumentary muscles are well developed; *e.g.*, in the hedgehog, porcupine, porpoise, etc.

Occipitalis Minor. This is the name given to a bundle of muscular fibres arising from the fascia over the upper end of the trapezius and ending in the fascia over the upper end of the sterno-mastoid. It is probably a modification of the slip which occasionally joins the platysma from the mastoid process or occipital bone.

Sterno-cleido-mastoideus. This muscle is usually considered to be made up of two muscles, the sterno-mastoid and cleido-mastoid. Krause, however, regards it as consisting of four muscles, viz.: (1) Sterno-mastoid, (2) sterno-occipital, (3) cleido-occipital, (4) cleido-mastoid. The spinal accessory nerve pierces the cleido-mastoid, or runs between the cleido-occipital and cleido-mastoid. Krause suggests the name *sterno-cleido-mastoideo-occipitalis*, or the *musculus quadrigeminus capitis*. He says that the ordinary varieties in man are readily explained by the isolation or absence of particular parts, or by the extension of the cleido-occipitalis to the occipital protuberance. Both the cleido-occipitalis and sterno-occipitalis may be feebly developed, or both may be absent, as, indeed, may be the sterno-mastoid. Again, the cleido-occipital or cleido-mastoid may be developed as separate muscles. The views of Krause are supported both by human and comparative anatomy. However, for ordinary purposes it is sufficient to regard the sterno-mastoid as consisting of two muscles. These two portions may be completely separate, or may join together at a much higher point than usual. This separation of the muscles into two is the normal condition in the greater number of mammals; *e.g.*, ruminants, solipeds, the majority of carnivora, and many of the anthropoid apes.

The sterno-mastoid and cleido-mastoid muscles may be completely fused—a condition which is not of great rarity.

Sternal attachment of the muscle may vary; the two sternal tendons may unite on the sternum or cross each other. The writer has seen the sternal tendon of one side continuous with a musculus sternalis of the opposite side (see Fig. 2353).

The sternal tendon may in rare cases be divided into two portions, inserted separately into the sternum. The sternal portion has been noted absent by Macalister. A

sesamoid bone is sometimes seen in the tendon of the sterno-mastoid; this is looked upon as a rudiment of the episternal bone of monotremes and lizards.

The clavicular portion varies considerably as to the extent of its attachment to the clavicle; it not infre-

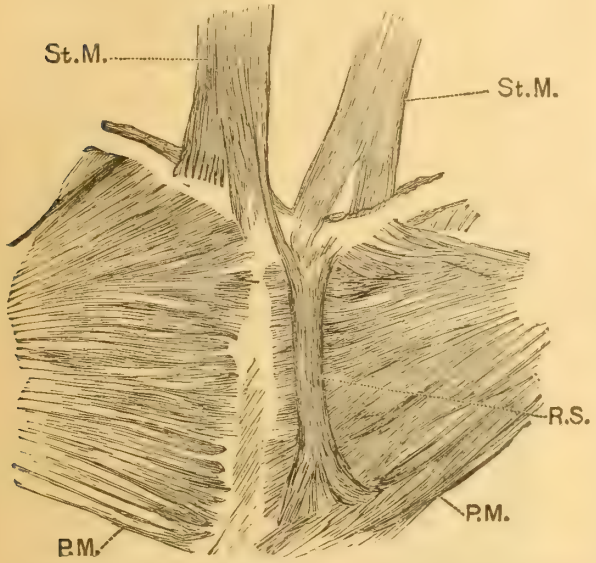

FIG. 2353.—*R.S.*, rectus sternalis continuous with (*St. M.*) sterno-mastoid of the opposite side. (Shepherd.)

quently covers the space called the subclavian triangle, and this should be borne in mind when performing the operation of ligature of the subclavian artery in its third part. The writer once, when operating on the neck, found the clavicular portion absent. In animals without clavicles the cleido-mastoid forms part of the cephalo-humeral muscle, being continuous with the outer portion of the pectoralis major or deltoid.

Cleido-occipital (Cephalo-humeral of Flower). This is a muscle described by Wood and others as arising from the clavicle outside the cleido-mastoid and inserted into the superior curved line of the occipital bone close to the origin of the trapezius. It is usually separated by a distinct areolar interval from both the sternal and clavicular fibres of the sterno-cleido-mastoid (see Fig. 2354).

This muscle corresponds to the cleido-occipitalis of Krause. It exists as a separate muscle in the guinea-pig, hedgehog, etc. In apes and monkeys it is always present, but is in them continuous with the hinder border of the true sterno-cleido-mastoid. In many of the carnivora, as the dog and cat, it forms part of the cephalo-humeral muscle. Wood found this muscle thirty-seven times in one hundred and two subjects.

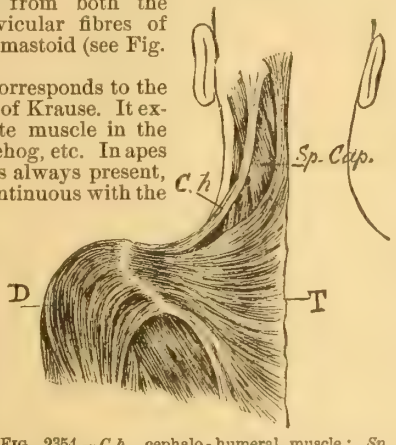

FIG. 2354.—*C.h.*, cephalo-humeral muscle; *Sp. Cap.*, splenius capitis. (After Flower, from the dissection of a Bushwoman, Jour. of Anat. and Phys., vol. i.)

The sterno-mastoid has been described as sending slips to the angle of the lower jaw and hyoid bone (Gruber). The sterno-hyoid and omo-hyoid, and in rare cases the trapezius, may unite with the sterno-mastoid.

A tendinous intersection is sometimes seen near the lower end of the muscle; the same intersection is seen in the sterno-hyoid and sterno-thyroid muscles; it is probably the remains of one of the transverse septa of the primitive ventral muscle-plate. These intersections are seen normally in the rectus abdominis.

Levator Claviculæ arises from the clavicle, and is inserted into the cervical vertebræ. A fuller description of this muscle will be given further on, under Muscles of the Upper Limb.

Supraclavicularis is a small muscle behind the sterno-mastoid, which arises by a slender tendon from the first piece of the sternum, crosses above the sterno-clavicular articulation, and is inserted into the upper surface of the clavicle. When present on both sides the muscles may be continuous in the middle line.

Transversus Nuchæ. This is described by many anatomists as a normal muscle, which is always represented when absent by tendinous fibres. It arises from the external occipital protuberance, and is inserted into the aponeurosis of the sterno-mastoid (see Fig. 2355).

Sterno-hyoideus occasionally arises only from the clavicle. In such cases there is a wide interspace at the root of the neck devoid of muscle. The writer in one case saw, on both sides, the sterno-thyroid and sterno-hyoid arise altogether from the clavicle an inch outside the sterno-clavicular articulation. On removing the skin and fascia the trachea and thyroid gland immediately came into view.

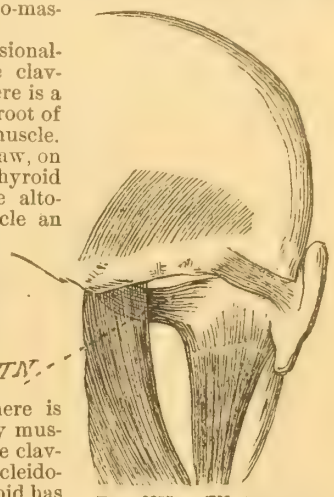

FIG. 2355. — *TN*, transversus nuchæ. (After Henle.)

This muscle is occasionally double. There is sometimes an accessory muscle seen going from the clavicle to the hyoid bone (cleido-hyoid). The sterno-hyoid has been described as occasionally arising from the sterno-clavicular ligament and first costal cartilage. It is sometimes fused with the muscle of the opposite side, as in the horse. The muscular fibres are not infrequently interrupted by a tendinous intersection, which is generally on a line with the tendon separating the two bellies of the omo-hyoid. This intersection is seen normally in some animals, as the chimpanzee, horse, etc. The muscle has been noted as absent on one side. It may be united by slips with the omo-hyoid, mylo-hyoid, or sterno-thyroid. All the anomalies above mentioned have their corresponding normal condition in the lower animals.

Sterno-thyroideus. Occasionally some of the fibres of this muscle continue on upward and are inserted into the hyoid bone with the omo-hyoid, or are continuous with the hyo-glossus muscle. A few fibres may be continued into the thyro-hyoid or inferior constrictor of the pharynx. In one case the writer saw it, on both sides, arise, with the sterno-hyoid, entirely from the clavicle. Walsham reports a case ("St. Barth. Hosp. Rep.," 1880) where the right sterno-thyroid arose from the left as well as the right side of the sternum and crossed the trachea. The left muscle was rudimentary. This muscle would be a source of embarrassment in performing tracheotomy.

In the gorilla and chimpanzee some fibres usually arise from the clavicle. The two sterno-thyroid muscles are often united at their origins across the middle line. Doubling of the muscle, as well as absence, has been observed. A tendinous intersection is sometimes seen opposite the tendon of the omo-hyoid. It may exist in both the sterno-hyoid and sterno-thyroid in the same line.

Costo-fascialis. Wood describes a slip arising with the sterno-thyroid from the hinder part of the first rib, which crosses the carotid vessels to be inserted into the cervical fascia as high as the thyroid cartilage.

Sterno-fascialis. This is a slip described by Gruber as

arising from the first piece of the sternum behind the sterno-mastoid, and passing upward to be inserted into the fascia of the subclavian triangle. It might be called the tensor fasciæ colli

Thyro-hyoideus. This muscle is often fused with the sterno thyroid, and in such cases the sterno thyroid is inserted into the hyoid bone. Absence of this muscle has been reported; this is generally due to a fusion of the sterno-thyroid and thyro hyoid, so that they form one muscle, which is inserted into the hyoid bone. The muscle may be divided into two distinct slips.

Crico-hyoid. Walsham first described this muscle as arising from the lower border of one side of the cricoid cartilage and inserted into the lower border of the hyoid bone. Gruber also mentions its occurrence.

Depressor Thyroideæ. A small muscle described by Bradley as arising from the first tracheal ring, passing over the cricoid cartilage and inserted into the lower border of the thyroid cartilage.

Omo-hyoideus. This muscle is frequently abnormal. In 250 subjects examined the writer found anomalies of the omo-hyoid in 39, or about 1 in 6. The muscle may be completely absent, and in rare cases it has been noted double. Again, one or other of its bellies may be wanting. When the anterior is absent, the posterior belly ends in the cervical fascia beneath the sterno-mastoid. In 250 subjects the writer has seen this arrangement twice. Sometimes the anterior belly arises from the clavicle and ascends the neck directly to its insertion into the hyoid bone without having any intermediate tendon or intersection. This has been regarded by some as absence of the posterior belly. The writer has only in one subject seen this anomaly; it occurred on both sides. This muscle has been called the *cleido-hyoid.* In some rare cases, however, the posterior belly is altogether absent, the anterior arising from the fascia covering the subclavian triangle (*hyo-fascialis*).

FIG. 2356.—Shows the omo-hyoid muscle continuing up over the hyoid bone to be inserted into the inferior maxilla; also, the muscular belly going from the tendon of the digastric to be inserted into the body of the hyoid bone. (Shepherd.)

The posterior belly not infrequently arises from the clavicle solely. In 120 subjects examined, the writer has seen this arrangement 8 times (1 in 15). The posterior belly may be double, the supernumerary portion arising from the clavicle. The writer has seen this occur 9 times in 120 subjects. In these cases the origin from the clavicle is generally extensive, and is from the middle third of the posterior border for a distance of two and sometimes three inches. In rare cases it may arise from the sternal end. The posterior belly of the omo-hyoid may be so bound down by fascia to the clavicle that the subclavian triangle is obliterated. In ligaturing the subclavian, it would be well for surgeons to bear in mind this occasional arrangement. This condition is present more frequently when the posterior belly arises from the clavicle.

The omo-hyoid being originally fused with the sterno-hyoid, it would be natural to see the lower portion occasionally displaced and have its origin from any of the osseous points between the scapula and sternum, or to receive supernumerary heads from the various points.

The scapular head of the omo-hyoid, besides having an accession from the clavicle, may receive one from the coracoid process, the acromio-clavicular joint, the acromion process, and even the first rib.

The anterior belly of the omo-hyoid is occasionally double. The writer has seen this anomaly three times. In the first case the supernumerary belly was inserted into the superior cornu of the thyroid cartilage; in the second, into the great cornu of the hyoid; and in the third it blended with the sterno-hyoid.

The anterior belly not infrequently blends with the sterno-hyoid so as to form one broad muscle, which is occasionally bounded below by an arched tendon, as in the seal. This fusion is due to the non-differentiation of the primitive brachio-cephalic sheet from which these two muscles are developed.

The writer has twice seen a portion of the omo-hyoid muscle pass over the hyoid bone and go up between the anterior bellies of the digastrics to be inserted into the lower jaw near the symphysis (see Fig. 2356).

The omo-hyoid may send slips to muscles in the neighborhood; *e.g.*, sterno-mastoid, sterno-hyoid, and the various muscles of the submaxillary region. A slip has been seen going from the posterior belly to the transverse process of the sixth cervical vertebra.

The intermediate tendon of the omo-hyoid may be absent or represented by a tendinous intersection.

Comparative Anatomy. The omo-hyoid is completely wanting in many animals, as the cat, dog, peccary, mole, etc., and also in rodents without clavicles. The anterior belly is absent in the orang-outang. The muscle arises from the clavicle in the scink and in some of the bats and the iguana. The intermediate tendon is absent in many mammals, as the echidna, ornithorhynchus, the American black bear, and some of the quadrumana. In the seal the anterior belly is fused with the sterno-hyoid and is bounded below by an arched tendon.

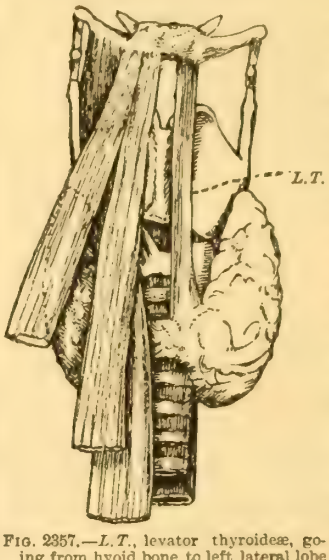

FIG. 2357.—*L.T.*, levator thyroideæ, going from hyoid bone to left lateral lobe of thyroid body. (Quain.)

Levator Glandulæ Thyroideæ. This is a fibrous or muscular band which goes from the body of the hyoid bone to the isthmus or one of the lateral lobes of the thyroid gland. There may be two or three slips. The writer, in one subject, on both sides, saw this slip proceed from the oblique line of the thyroid cartilage and go to each lateral lobe of the gland. The levator thyroideæ is looked upon as an aberrant portion of the muscles between the sternum and hyoid bone (see Fig. 2357).

Digastricus. The digastric muscle is subject to many variations. Occasionally its tendon fails to pierce the stylo-hyoid. The *anterior belly* is very often abnormal: not infrequently the two anterior bellies unite in the median line and completely shut out from view the mylo-hyoid muscles. The two bellies often decussate, as in the Norway rat and ruminants. It is not uncommon to find the anterior belly divided into two or more parts, one of which may cross the middle line of the neck and join the anterior belly of the opposite side. A slip from the anterior belly may join the mylo-hyoid, or decussate in the middle line with a similar slip from the opposite muscle. These slips may be looked upon as varieties of the mento-hyoid muscle, described below. In one subject the writer saw a well-marked muscular slip given off from the intermediate tendon and inserted into the body of the hyoid bone (see Fig. 2356). Also, in another subject there was complete absence of the anterior belly on the left side; the posterior belly ended in the deep cervical fascia attached between the hyoid bone and angle of the jaw. This might be regarded as a form of the monogastric muscle, which is well seen in the lower animals, as

the carnivora. MacWhinnie describes a case where the muscle was monogastric and was inserted into the middle of the body of the lower jaw. In rare cases a muscular slip from the angle of the jaw joins the anterior or posterior belly. The writer once saw a well-marked tendinous slip going from the angle of the jaw to the posterior belly.

The *posterior belly* occasionally receives accessory slips from the styloid process. It has been seen arising entirely from the styloid process. It is sometimes connected by a muscular slip with one of the constrictors of the pharynx. Walsham describes a tendinous intersection, and in one case a distinct tendon, occurring in the posterior belly. The posterior belly has been seen to pass behind instead of in front of the carotid artery.

Occipito-hyoid. Perrin (*Jour. Anat. and Phys.*, vol. v.) first described this muscle as an additional digastric; he considered it as homologous with the stylo-hyoid of birds. The muscle is double-bellied; its posterior belly arises from fascia covering the occipital bone, and its anterior belly is inserted into the hyoid bone beneath the hyo-glossus. Humphry looks upon it as a superficial appendage to the stylo-hyoid and digastric muscles. There is a similar muscle in the seal.

Mento-hyoid (Macalister). This is the name given to a slip of muscle of variable size, and sometimes double,

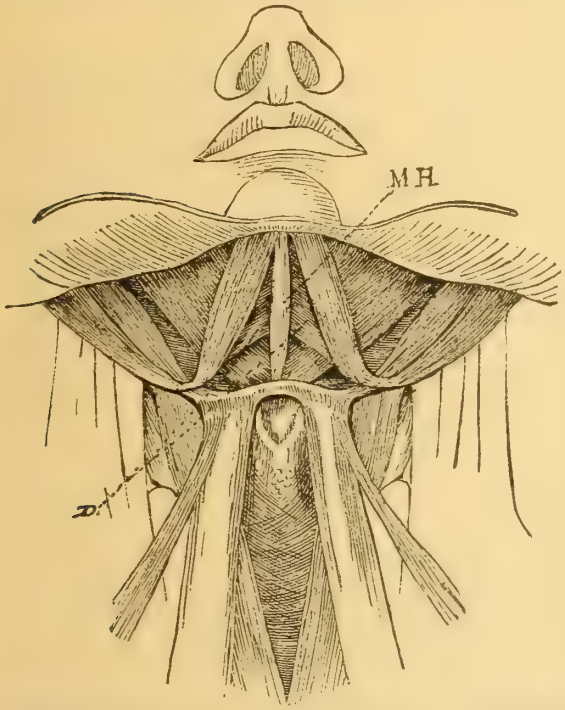

Fig. 2358.—Showing mento-hyoid muscle (*MH*); also, the anterior bellies of the digastric muscles united in the middle line by muscular fibres (*D*). (Shepherd.)

which is not infrequently seen passing, superficial to the mylo-hyoid, from the lower jaw near the symphysis to the body of the hyoid bone. Occasionally the muscle does not reach the hyoid bone, but ends in a fascia which covers the mylo-hyoid and is attached to the bone. It is sometimes triangular in shape. Macalister looks upon the mento-hyoid as a differentiated portion of platysma; but it is probably more closely related to the anterior belly of the digastric and the sterno-hyoid group, which are formed from the superficial brachio-cephalic stratum of muscle (see Fig. 2358). The mento-hyoid exists normally in many animals, as the bat, hippopotamus, etc.

Stylo-hyoideus. Occasionally absent. Testut suggests that in cases of supposed absence of this muscle it is fused with the posterior belly of the digastric. A division of the muscle into three has been noticed. It may sometimes pass behind the carotid artery. It is occasionally inserted into the tendon of the digastric or lesser cornu of the hyoid bone. Its fibres may be continuous with the mylo-hyoid, thyro-hyoid, omo-hyoid, or, as in the ant-eater, with the muscles of the tongue. It sometimes arises from the lower jaw and goes to the hyoid bone (hyo-maxillaris); again, it may not reach the hyoid bone, but go from the styloid process to the angle of the lower jaw, as in birds (stylo-maxillaris). The writer has seen this muscle absent in two subjects, once on both sides.

Stylo-chondro-hyoideus (Douglass); *Stylo-hyoideus alter* (Albinus). This is an additional muscle, which occasionally replaces the normal stylo-hyoid and has the course of the stylo-hyoid ligament; in other words, it is the stylo-hyoid ligament become muscular. It is inserted into the lesser cornu of the hyoid bone and passes behind the carotid artery. In one case, noted by the writer, where this muscle existed the normal muscle was represented by a thin tendinous slip. The normal stylo-hyoid and this muscle frequently are present together. The stylo-hyoideus alter may receive a slip from the lower jaw. In 120 subjects the writer has seen this muscle 9 times; 3 times it occurred on both sides of the same subject.

Stylo-hyo-thyroideus. This is the name given by the writer to a muscle seen by him in a female subject in the anatomical rooms of McGill University during the winter session 1885–86. On both sides of a thin female subject, in addition to the usual stylo-hyoid, a stylo-chondro-hyoid was present. On the left side this muscle gave off a slip to the middle constrictor of the pharynx. On the same side, arising in common with the stylo-chondro-hyoid, was another muscle of the same size, this had a well-developed belly, and passed down posterior but parallel to the above-mentioned muscle to a little above the hyoid bone; here it left its companion and developed a well-formed round tendon, which passed under the middle constrictor and was inserted into the tip of the superior cornu of the thyroid cartilage. The stylo-pharyngeus was of normal size and insertion.

Mylo-hyoid. The median raphé between the two muscles is sometimes absent. The mylo-hyoid is often closely united to the anterior belly of the digastric, and may be partially replaced by it. The sterno-hyoid, omo-hyoid, or stylo-hyoid, may send slips to it. The muscle may be divided into two portions, an anterior and posterior, separated by a considerable interval. This is the arrangement in some of the rodents. A deficiency of the fore part is of common occurrence, the origin not reaching farther than the canine tooth (Quain).

Genio-hyoideus. The two muscles may be fused in the middle line. It occasionally receives a slip from the great cornu of the hyoid bone. It may be closely united with the genio-hyo-glossus or hyo-glossus.

Genio-hyo-glossus. This muscle has been found united with the genio-hyoid. The two muscles may be fused together, no cellular interval separating them. Slips have been seen going from the genio-hyo-glossus to the epiglottis, stylo-hyoid ligament, and lesser cornu of the hyoid bone. An accessory muscle has been described by Henle, Luschka, and Bochdalek, going from the mental spine to the hyoid bone between the two genio-hyo-glossi muscles.

Hyo-glossus. Sometimes pierced by the lingual artery. The middle portion of the muscle is occasionally absent, leaving a larger or smaller interval between the outer and inner portions, and exposing the lingual artery (see Fig. 2359). The lingual artery may lie on the muscle instead of beneath it.

Tritico-glossus (Bochdalek). This is a small muscular slip which arises from a cartilaginous nodule in the thyro-hyoid ligament, and passes upward and outward to join the posterior part of the hyo-glossus.

Chondro-glossus. This has been described as a distinct muscle, occurring normally, separated from the hyo-glossus by the pharyngeal fibres of the genio-glossus. It arises from the base of the lesser cornu and, spreading out, is inserted into the dorsum of the tongue near the middle line.

Stylo-glossus. The stylo-glossus is occasionally absent.

The writer once saw it absent on both sides of the same subject. There is sometimes an additional origin, from the angle of the lower jaw or the stylo-maxillary ligament. The whole muscle may arise from these points, the styloid origin being absent. When it arises from the angle of the jaw it is called the *mylo-glossus*. Gruber has described a rare origin of this muscle, from the external auditory meatus (*chondro-glossus*). The muscle may be divided into two portions; one of which is inserted normally, the other into the pharynx (Sandifort). Macalister has reported this muscle as double. Henle has described a slip going from the stylo-glossus to the genio-glossus near its origin.

Muscles of the Pharynx.—Constrictor Superior. The second portion may be distinct. Meckel describes an accessory slip, arising from the pharyngeal spine and becoming lost in the middle line of the posterior wall of the pharynx. The writer once, on both sides of the same subject, saw this muscle receive a slip from the Eustachian cartilage.

Constrictor Medius occasionally receives fibres from the stylo-hyoid ligament or hyoid bone; also from the tongue and hinder part of the mylo-hyoidean ridge. It is common to see a slip from the thyro-hyoid ligament

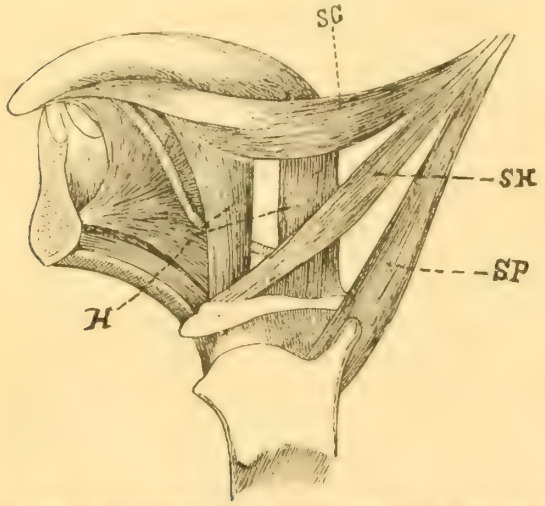

FIG. 2359. *H*, hyo-glossus muscle deficient in its central portion; *SG*, stylo-glossus; *SH*, stylo-hyoid; *SP*, stylo-pharyngeus. (Waisham.)

(*syndesmo pharyngeus*, Douglass). The upper fibres of the muscle may reach the occipital bone.

Constrictor Inferior. A few fibres of origin may come from the trachea. It is occasionally connected by muscular slips with the crico-thyroid, sterno-hyoid, or sterno-thyroid muscles.

Stylo-pharyngeus. Cleavage of this muscle into two or even three parts has been noted. Gruber has described a double-headed stylo-pharyngeus. The accessory head in his case arose from the mastoid process.

Supernumerary Muscles of the Pharynx are not infrequently present, proceeding from the lower part of the base of the skull and going to one of the constrictors or passing between these muscles and the fibrous layer of the pharynx. They may arise from the petrous portion of the temporal (*petro-pharyngeus*), spine of the sphenoid (*sphæno-pharyngeus*), hamular process (*pterygo-pharyngeus*), basilar process (*occipito-pharyngeus*), or from the pharyngeal tubercle of the occipital bone (*azygo-pharyngeus*).

PREVERTEBRAL MUSCLES.—*Scalenus Anticus.* Absence of the muscle has been reported by Macalister. In this case the subclavian vein was in direct contact with the artery. The attachment to the cervical vertebræ may vary in extent. The muscle may be divided into several distinct portions. It is sometimes pierced by the subclavian artery, and in rare cases lies behind the artery, or, more properly speaking, the artery passes in front of it.

Scalenus Medius and Posticus. These two muscles are so intimately united that French anatomists regard them as one muscle. They vary considerably as to the extent of their attachments to the transverse processes of the cervical vertebræ; frequently the slips from the upper cervical are absent. In rare cases the posterior scalenus may be attached as far down as the third and even the fourth rib, as in many of the lower animals. In some animals, as the bear, it reaches as far as the seventh and eighth ribs. In man it is not infrequently absent. The scalenus medius is perforated by branches of the brachial plexus and frequently by the posterior scapular artery.

Scalenus Minimus (Albinus). This is a small slip of muscle, normal in apes, which is seen in man occasionally. It passes from the transverse processes of the lower cervical vertebræ to the first rib, behind the subclavian artery, and in front of the brachial plexus.

Transversalis Cervicis Medius (Törnblom). Under this name a muscle has been described as arising from the transverse processes of the second, third, and fourth cervical vertebræ, and inserted into the sixth and seventh cervical transverse processes.

Rectus Capitis Anticus Major. Varies occasionally in the extent of its attachment to the cervical vertebræ. It is sometimes strengthened by a fasciculus from the transverse process of the axis, and has been noted as having no origin from the sixth cervical. It is frequently united with neighboring muscles, as the anterior scalenus, transversalis cervicis, etc.

Rectus Capitis Anticus Minor. Occasionally has a slip from the axis. Macalister has described a supernumerary muscle attached to the anterior portion of the atlas (M. rect. ant. medius of Gruber).

Longus Colli. The longus colli is subject to some variations in the number of its attachments and in the degree of separation of its constituent parts. The lower oblique portion may send a slip to the head of the first rib. It is also sometimes prolonged to the rect. cap. ant. major, and has been seen sending a slip of insertion to the basilar portion of the occipital bone. A supernumerary longus colli (*M. transversalis cervicis ant.*, Luschka) may arise by thin, tendinous slips from the anterior tubercles of the transverse processes of the lower four cervical vertebræ and be inserted by two tendons into the base of the transverse process of the atlas and the body of the axis (Henle).

MUSCLES OF THE UPPER LIMB.—*Trapezius* (Cucullaris). The attachments of this muscle are subject to considerable variation. The muscle may be much smaller than usual, and have no occipital origin or be attached to as few as six instead of twelve dorsal spines; it may be divided into a cervical and dorsal portion. Again, its spinal attachments may be confined to the upper three or four dorsal, or lower three or four cervical spines, the other portions being absent. It is sometimes inserted into more of the clavicle than normal, being continuous with the insertion of the sterno-mastoid. Occasionally there is a slip passing forward across the subclavian triangle to reach the sterno-mastoid; this would be in front of the third part of the subclavian artery, and interferes somewhat with the operation of ligature of that artery. Again, it may be continuous with the deltoid, as is the case in animals without clavicles. In rare cases the portion attached to the clavicle is absent or very small. This arrangement is seen in some of the lower animals. A slip has been described going from the anterior border of the muscle near the clavicle to the sternum; this is a variety of the sterno-scapular muscle. Not infrequently slips of attachment unite the trapezius to the levator anguli scapulæ.

Latissimus Dorsi. The number of dorsal vertebræ to which this muscle is attached may vary considerably. It may be attached to as many as nine, and as few as four. The writer has seen it attached to all the dorsal vertebræ. Its attachments to the ribs also vary, the number being sometimes increased, sometimes diminished. It is occasionally attached to the lower angle of the scapula; the writer has twice seen it send slips to the spine of the scapula.

Axillary Band (Achselbogen). This is a muscular

band which crosses the lower part of the axilla from the latissimus dorsi to the great pectoral muscle near its insertion (see Fig. 2360).

It may, instead of uniting with the great pectoral, be inserted into the coraco-brachialis or fascia covering the biceps. In its course it usually crosses the axillary ves-

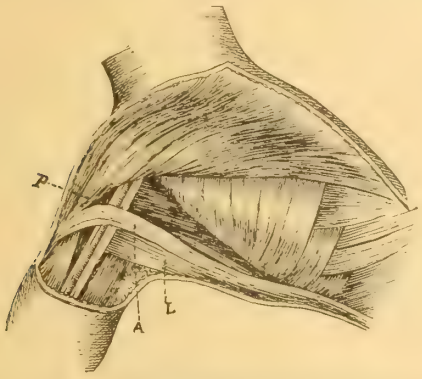

Fig. 2360.—*A*, Axillary Band, between the latissimus dorsi (*L*) and the great pectoral (*P*).

sels, and hence it is well to bear this in mind in ligaturing the axillary artery in its third part. It is sometimes of large size, being as broad as 6.2 centimetres, and so may cover a considerable extent of the axillary vessels. More frequently it is a small slip, one to three centimetres broad. It occurs in about five per cent. of all subjects, and is frequently on both sides of the same subject. The writer has seen it in eleven subjects out of two hundred and fifty noted. This muscular band exists normally in many animals, as deer, etc., and is the remains of the continuity which previously existed between the latissimus dorsi and the pectoralis major.

Dorso-epitrochlearis. This is a muscle which is occasionally seen in man in a rudimentary form, but in many of the lower animals, as apes, lemurs, seals, bears, etc., is a well-developed muscle, and is the normal arrangement. It is a muscular slip which is given off from the lower border of the tendon of the latissimus dorsi, and is attached to various points in the arm. It may end in the long head of the triceps, some portion of the internal intermuscular septum, the epitrochlear process of the internal condyle, or the olecranon process (see Fig. 2361). In man the muscle is occasionally represented merely by a fibrous band, sometimes by a small, muscular slip ending in a fibrous cord, which is inserted into the internal condyle, or is continuous with the internal intermuscular septum.

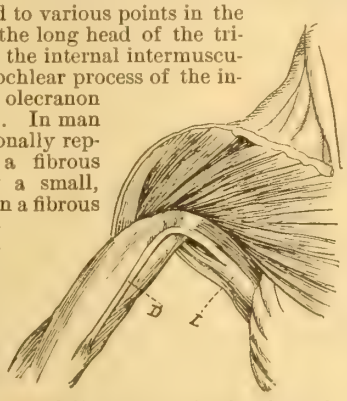

Fig. 2361.—*D*, dorso-epitrochlearis muscle; *L*, latissimus dorsi. (Perrin.)

Rhomboideus Minor and Major. Both these muscles are subject to variation as to extent of origin and insertion. They may be divided into two fasciculi, as in some animals.

Rhombo-occipital (occipito-scapular of Wood). This is a slip not infrequently seen in man, and which occurs normally in many of the lower animals, *e.g.*, the deer, cat, tiger, etc., as a well-developed muscle immediately beneath the trapezius, and reaching from the occiput to the base of the spine of the scapula. In man it generally exists in an incomplete form, and varies considerably as to its upper and lower attachments. Instead of reaching the scapula it may be connected with either of the rhomboid muscles, serratus posticus superior, or levator anguli scapulæ. Its superior attachment may not reach the occiput, but be connected with the spines of the upper cervical vertebræ. Again, in man, this muscle may be represented by a slip from the aponeurosis covering the splenius capitis to the spine of the scapula, or by a slip from the levator anguli scapulæ to one of the rhomboids. In one case recorded by the writer it consisted of a well-developed muscular slip reaching from the transverse process of the atlas to the aponeurosis over the greater rhomboid (*rhombo-atloid* of Macalister). The many varieties of this muscle in man have been carefully described by Professor J. Wood ("Proceed. Roy. Soc.," 1870—see Fig. 2362).

Levator Anguli Scapulæ. This muscle varies considerably in the extent of its attachments to the vertebræ and scapula. It is often seen attached to as many as six vertebræ and to as few as two. It has been seen arising from the mastoid process and occipital bone in addition to its spinal origin. It may have an attachment to the spine of the scapula, and it sometimes sends slips of insertion to the first or second rib. Occasionally it is seen divided into two or more slips, the portions connected with the different vertebræ remaining separate. It is often connected with neighboring muscles by muscular slips. The writer has seen it thus connected with the serratus posticus superior, serratus magnus, deep surface of the trapezius, complexus, splenius capitis, rhomboideus minor, and scalenus posticus. These slips are regarded by Wood as varieties and modifications of the occipito-scapular muscle of the lower animals. In many of the lower animals the levator anguli scapulæ is merely the upper portion of the serratus magnus, forming with it a single muscle.

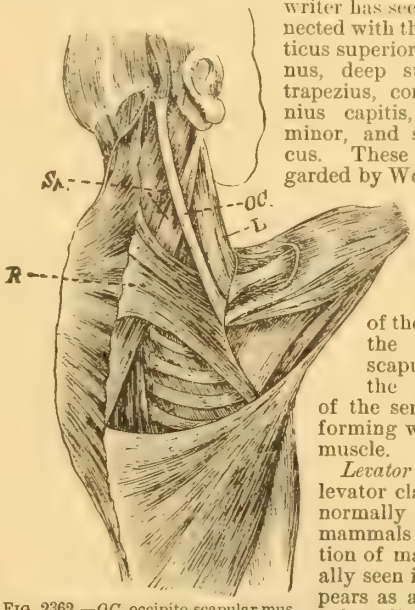

Fig. 2362.—*OC*, occipito-scapular muscle; *L*, levator anguli scapulæ; *R*, rhomboid muscles; *Sp*, splenius. (Wood.)

Levator Claviculæ. The levator claviculæ, which normally exists in all mammals with the exception of man, is occasionally seen in him. It appears as a separate muscular slip arising from the transverse processes of one or two upper cervical vertebræ, and inserted into the outer end of the clavicle. Slips of muscle from the levator anguli scapulæ, or from the upper cervical spines, to the scalene muscles, serratus magnus, and ribs, are regarded as modifications of the levator claviculæ.

Cleido-cervicalis (Gruber). This is a form of the above muscle arising from the transverse process of the sixth cervical and inserted into the outer end of the clavicle. Gruber looks upon it as a supernumerary scalene muscle attached to the clavicle.

Pectoralis Major. Many variations of this muscle have been observed. The more common varieties consist of a greater or less extent of attachment to ribs and sternum, and the separation of its clavicular from its costal attachment.

M. Testut divides the anomalies of this muscle into eight groups, viz. :

1. Fusion of the clavicular portion with the deltoid.
2. Fusion with the great pectoral of the opposite side.
3. Union with the rectus abdominis.
4. Union with the biceps brachii (see Fig. 2369).
5. Separation of the clavicular and sterno-costal portions by an interspace.

6. Division of the costo-sternal portion into two strata or layers.

7. Anomalies in the mode of insertion into the arm.

8. Complete or partial absence of the muscle.

Testut divides the anomalies of the brachial insertion into: (*a*) Insertion into the coracoid process and aponeurosis of the coraco-brachialis. (*b*) Insertion into the capsule of the shoulder-joint. (*c*) Prolongation of the tendon of insertion into the capsule of the shoulder-joint. (*d*) Supernumerary insertion into the humerus. (*e*) Insertion into the brachial aponeurosis. (*f*) Insertion into the two lips of the bicipital groove.

Fig. 2363.—Example of the Chondro-epitrochlearis Muscle (*C*). (Perrin.)

Chondro-epitrochlearis (Duvernoy). This is the name given by Duvernoy to a muscular slip which is sometimes seen arising from the cartilage of one or two ribs, the aponeurosis of the external abdominal oblique, the lower border of the great pectoral itself, or its tendon; from one of these origins it passes down and out, and is inserted in a variable way into the arm. It is often inserted into the internal intermuscular septum and occasionally reaches as far as the internal condyle of the humerus.

Mr. J. B. Perrin (*Jour. Anat. and Phys.*, vol. v.) has described, under the name of epigastric slips a number of muscles connected with the lower border of the pectoralis major, or arising separately from the sixth or seventh rib and inserted into the tendon of the great pectoral, or into the fascia covering the coraco-brachialis muscle (see Fig. 2363). They may also be connected with the latissimus dorsi. These muscles are developed to a high degree in many mammals, and are well seen in pigeons and fowls.

Musculus sternalis. Syn.: Rectus sternalis, sternalis brutorum (Albinus), présternal (Testut). The musculus

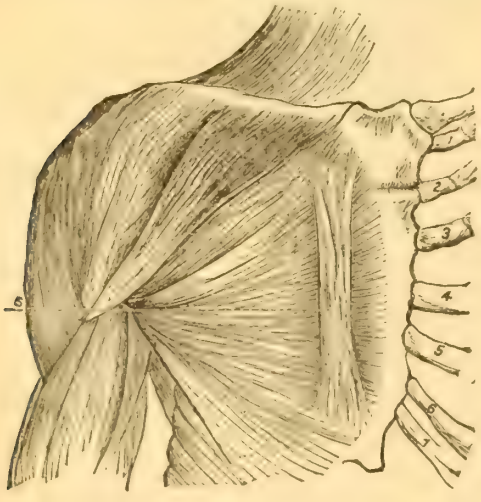

Fig. 2364.—*S*, Musculus sternalis, attached above and below to fascia. (Shepherd.)

sternalis is a supernumerary muscle which has always excited a great deal of interest among anatomists; even yet its proper morphological significance is not fully determined. It is seen in about three or four per cent. of ordinary individuals, but in anencephalous monsters is nearly always present. Its fibres are generally at right angles, and superficial to, the great pectoral; it is often bilateral, but more frequently unilateral, and is subject to many variations. Frequently it has no attachment to bone but rests on the great pectoral, attached above and below to fascia (see Fig. 2364). It is often attached to the sternum and costal cartilages of one side or both, and is occasionally continuous above with the sternal origin of the sterno-mastoid, and below, with the external abdominal oblique (see Fig. 2353).

It usually arises from the first piece of the sternum, and is inserted into some of the ribs and costal cartilages, generally the fifth and sixth. It may be continuous in part with the great pectoral itself and be associated with deficiency of that muscle. Sometimes it is of small size, but occasionally it is quite a large muscle, eight to ten centimetres long, and three to five centimetres broad. It has been recognized under the skin in the living. It derives its nerve-supply from the same source as the pectoral muscles, viz., the anterior thoracic. The muscle is regarded by Sir William Turner, Dr. Dobson, and others as a remnant of a skin muscle. Henle, Theile, Bourrienne, and others look upon it as a prolongation downward of the sterno-mastoid. Halbertsma thought it a muscle *sui generis*, peculiar to man, and having no animal repre-

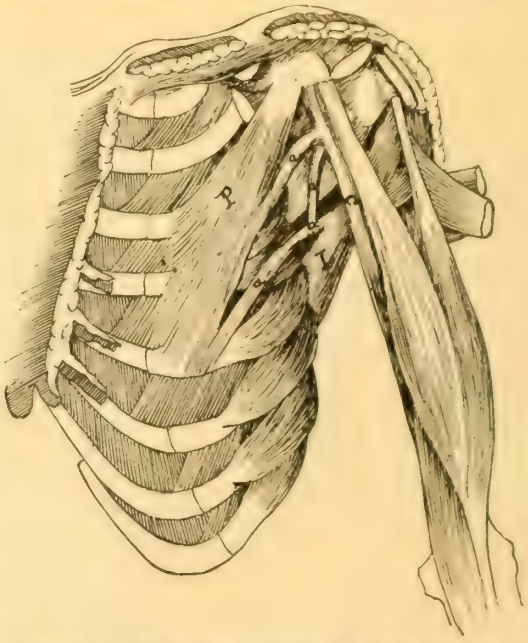

Fig. 2365.—*a*, *a*, *a*, Muscular slips connecting the pectoralis minor (*P*) with the coraco-brachialis (*C*) and the latissimus dorsi (*L*). (Shepherd.)

sentative. D. J. Cunningham thinks it a new inspiratory muscle appearing in man, and is of opinion that it occurs more commonly in females, costal inspiration being more pronounced in them. In dissections of anencephalous monsters made by the writer the nerve-supply was traced, in nearly all the specimens examined, to the anterior thoracic. These dissections convinced him that this muscle belongs to the pectoral and not the panniculus group (see *Jour. Anat. and Phys.*, vol. xix.).

Pectoralis Minor. The origin of this muscle varies considerably. It may arise from the second, third, and fourth ribs, instead of the third, fourth, and fifth. Not infrequently it arises from four ribs, and the writer has occasionally seen it arise by five digitations from the five upper ribs. It has been described as attached to only two ribs, and Testut, in his work on "Muscular Anomalies," describes a case where it arose by a single digitation from the fourth rib; in this case the subclavius muscle was of large size. Sometimes the pectoralis minor is divided into a number of slips corresponding with the ribs from which it arises. It is occasionally connected with the great pectoral. In one case the writer saw it connected by muscular slips with the latissimus dorsi and

coraco-brachialis, and these two slips were connected together by a third (see Fig. 2365).

The variations of insertion of the pectoralis minor are numerous. The muscle not infrequently passes over the coracoid process and is inserted into the capsule of the shoulder-joint and great tuberosity of the humerus. It very frequently is united at its insertion to the coraco-brachialis. In one case the writer saw it inserted into the coraco-brachialis by a tendinous expansion, five centimetres broad; in this case the coracoid process received no fibres of insertion. In many of the carnivora and quadrumana this muscle is normally inserted into the humerus. In rare cases the pectoralis minor is divided into two layers which have distinct insertions, and sometimes it is absent.

Pectoralis Minimus. Gruber has described a slip, to which he gives the above name, arising from the first piece of the sternum and cartilage of the first rib; from this origin it passes outward between the subclavius and lesser pectoral to be inserted into the coracoid process. Some regard it as a variety of the chondro-scapular muscle of Wood.

Subclavius. The subclavius is not infrequently inserted into the coracoid process as well as the clavicle; occasionally it has no clavicular attachment, but is wholly inserted into the root of the coracoid process. It has been described as double by some anatomists, but the supernumerary muscle will be described below as the sterno-scapular. Walsham describes a case where the subclavius had an insertion into the humerus, as is normally seen in birds. The subclavius is sometimes absent, its place being taken by the sterno-scapular.

Sterno-chondro-scapular (Wood). Syn.: Scapulo-costalis minor (Macalister), subclavius posticus (Rosenmuller).

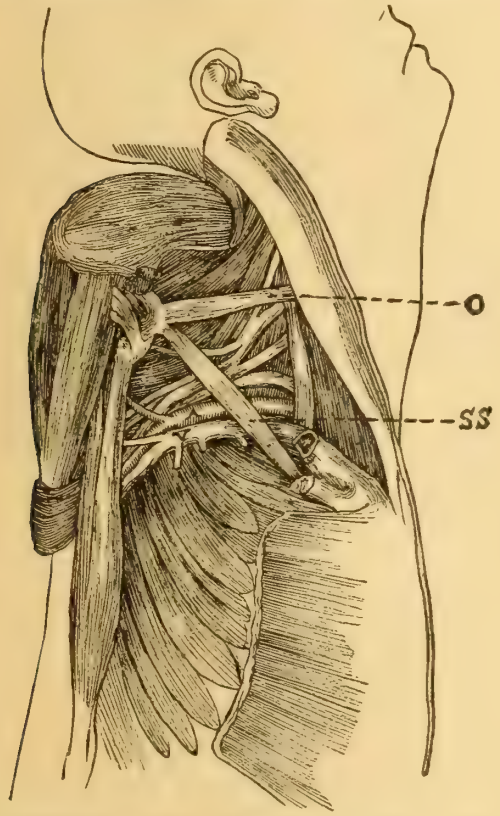

FIG. 2366.—*SS*, sterno-scapular muscle; *O*, omohyoid. (Wood.)

This is a supernumerary muscle of a somewhat cylindrical shape, which is attached externally to the root of the coracoid process or upper border of the scapula, passes inward over the subclavian artery and brachial plexus of nerves, beneath the clavicle and subclavius muscle, to be attached by a round tendon to the costal cartilage of the first rib, first piece of the sternum, or both (see Fig. 2366).

Sometimes this muscle passes over the clavicle in place of beneath it, and occasionally it does not reach as far as the coracoid, but may be inserted into the anterior border of the clavicle (sterno-clavicular ant.). A variety of the sterno-clavicular muscle which the writer has seen is one which reaches from the sterno-clavicular articulation to the anterior border of the trapezius. In its course it passes over the clavicle and across the subclavian triangle, covering the third portion of the subclavian artery (see Trapezius). In ligature of the subclavian it is well to bear this anomaly in mind. When the sterno-scapular muscle exists there is sometimes absence of the subclavius muscle; the writer has seen this occur once only out of 7 cases; in 3 cases, however, the subclavius was much reduced in size. W. Gruber saw absence of the subclavius in 7 out of 11 cases of sterno-scapular muscle.

Comparative anatomy: In the Norway rat, guinea-pig, wombat, etc., the sterno-scapular muscle is normally present. In the horse it is a well-developed muscle. In animals without clavicles having a sterno-scapular muscle it is regarded as the homologue of the subclavius.

Chondro-coracoid is a small muscle described by Wood as arising from the first costal cartilage by a round tendon, and, passing outward below the subclavius, is inserted into the coracoid process superficial to the coraco-brachialis.

Many other supernumerary clavicular muscles have been described, such as the scapulo-clavicular, coraco-clavicular, supra-clavicular, infra-clavicular, etc., but they are so rare that it is only necessary to mention them and refer readers wishing to learn more about them to the special works on muscular anomalies mentioned in the introduction to this article.

Serratus Magnus. The serratus magnus may arise from nine ribs instead of eight, and occasionally it receives a slip from the tenth. Again, some of the highest or lowest digitations may be wanting, the muscle thus being attached to only six or seven ribs. Occasionally some of the central digitations are absent, and the muscle is then divided into two portions. Wood has described two large muscular bands, distinct from the serratus, arising from the ninth and tenth ribs, and inserted into the inferior angle of the scapula. He regards these bands as homologues of the depressor scapulæ of birds. Sometimes there is more or less complete fusion of the serratus with the levator anguli scapulæ. In many mammals it forms one muscle with the levator.

MUSCLES OF THE SHOULDER.—*Deltoid.* This muscle is not subject to many variations. It is sometimes divided into several distinct portions, viz., the clavicular, acromial, and spinal, as in carnivora. The clavicular and acromial portions are often separated by an interspace; not infrequently the clavicular portion is intimately connected with the contiguous part of the great pectoral, the division between them being only determined by the cephalic vein. The clavicular portion may also, in some cases, be continuous with the fibres of the trapezius, as in animals without clavicles.

The insertion of the deltoid varies in position and extent; in some cases it is inserted much lower than usual. Macalister has described a rare anomaly of this muscle, viz., the prolongation of its tendon as far as the lower end of the radius; he considers this to be the homologue of the extensor plicæ alaris of birds.

Testut has described a slip going from the clavicular portion of the deltoid to the internal condyle, crossing in its course the brachial vessels; he calls it the *cleido-epitrochlearis*. The deltoid not infrequently receives accessory slips from the axillary or vertebral borders of the scapula, and also from the spine and subspinous aponeurosis.

Supra-spinatus. Variations of this muscle are extremely rare. It is very constant both as to its size and attachments. Occasionally fibres of the great pectoral are inserted into it. The writer once saw its tendon pass over the capsule of the shoulder-joint in a pulley-like depres-

sion, and become continuous with the deep portion of the insertion of the pectoralis major (see Fig. 2367).

Infraspinatus is occasionally fused with the teres minor. It may be connected with the deltoid by a strong

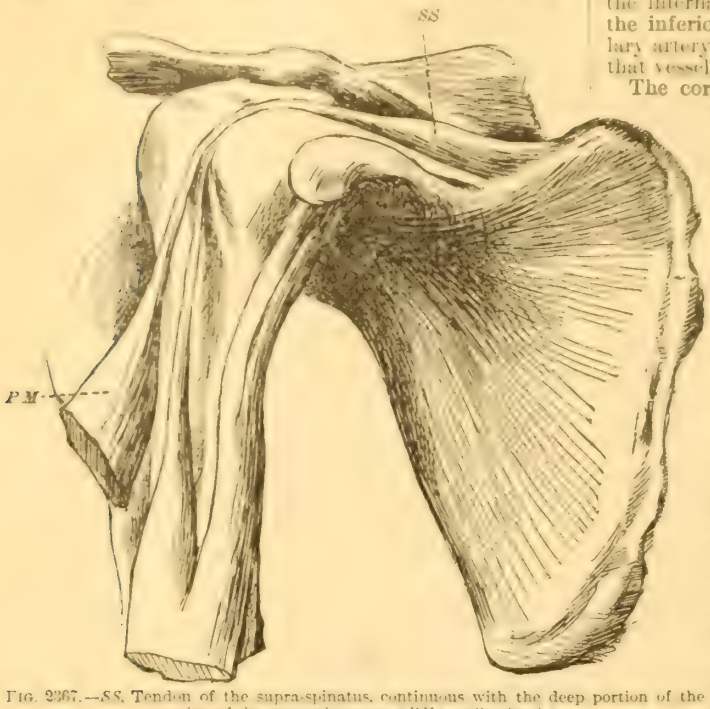

FIG. 2367.—*SS*, Tendon of the supra-spinatus, continuous with the deep portion of the tendon of the pectoralis major (*PM*). (Shepherd.)

fasciculus, and, again, it may be divided into several slips.

Teres minor is occasionally divided into two portions, the lower being called the teres minimus.

Teres major may be reduced to the size of the teres minor. It is sometimes inseparably connected with the latissimus dorsi, as in some of the lower animals. A fasciculus has been described descending on the fascia of the arm externally. It is analogous to the tensor fasciæ of the leg.

Subscapularis. Varies but little. A small accessory muscle (subscapulo-capsularis, subscapularis minor) has been described by W. Gruber, Macalister, and others, which goes from the axillary border of the scapula to the capsule of the shoulder-joint or humerus. Knott describes some fibres given off from the lower border of the subscapularis and inserted into the aponeurosis and skin of the axilla. These are regarded as remnants of the panniculus carnosus muscle of the lower animals.

Curnow, Walsham, and others, have described a muscle arising from the inner bicipital ridge, or the groove itself, and passing up to be inserted into the capsule of the shoulder-joint near the insertion of the coraco-brachialis. Testut describes this muscle under the name of *brachio-capsularis*.

Coraco-brachialis. Professor Wood (*Journ. of Anat.*, vol. i.), considers that this muscle consists typically of three portions—superior, middle, and inferior. In man the middle and part of the inferior portion exist most constantly, the two portions being separated by the musculo-cutaneous nerve. Both the superior and inferior divisions are, however, occasionally seen in addition to the middle division (*coraco-brachialis proprius*). The superior (*coraco-brachialis superior vel brevis*), when it exists in man, arises from the coracoid process, passes over the subscapularis muscle, and is inserted below the lesser tuberosity, or more rarely into the capsule of the shoulder-joint (*coraco-capsularis*). This is the normal arrangement in many animals, as the dog, cat, etc.

The inferior division (*coraco-brachialis longus*) is also occasionally seen. It may be of large size and be inserted into the internal condyle or into a supra condyloid process when that anomaly exists. It is sometimes represented at its lower portion by a fibrous band; this is the internal brachial ligament of Struthers. As a rule, the inferior portion, when present, passes over the axillary artery, and must be kept in mind when ligaturing that vessel. (See Fig. 2368.)

The coraco-brachialis occasionally is not pierced by the musculo-cutaneous nerve.

Comparative Anatomy: In animals which swim or climb, as the beaver, bear, etc., the *coraco-brachialis longus* is well developed. In most of the quadrumana there is a double insertion of the coraco-brachialis, and, in the guinea-pig, the median variety only is present, as in man. In some animals, as the kangaroo, the muscle is absent altogether. It has once been found absent in a human monster. The coraco-capsularis is present normally in many animals, e.g., the dog, cat, etc.

Biceps Brachii. This muscle is rich in varieties. The most common is the presence of a third head, which arises near the insertion of the coraco-brachialis, and in close connection with the brachialis anticus. The proportion of subjects having a third head is, in the writer's experience, one in seven; Theile makes it one in nine; Hallett, one in fifteen; Wood and Macalister, one in ten. In two hundred and fifty subjects examined the writer found it five times on both sides of the same subject. The third head generally soon joins the coracoid head about its middle, but it is occasionally seen quite separate as far as the bicipital fascia, into which it is inserted. The third head usually lies outside the vessels, but sometimes is seen covering them. It may arise from the bicipital groove, one of the ridges, or even from the great tuberosity. The writer has seen it arise from the lower edge of the great pectoral near its insertion. (See Fig. 2369).

The third head is regarded by some as an offshoot from the brachialis anticus. Struthers has described a muscular slip which comes off from the inner border of the biceps, passes over the brachial vessels, and is inserted into the internal intermuscular septum or internal condyle.

FIG. 2368.—*A*, coraco-brachialis longus passing over the brachial vessels (*Ax*) to reach the internal condyle; *C*, normal coraco-brachialis. (After Wood.)

The biceps has been seen with as many as four and even five heads. The supernumerary heads, as a rule, have their origin from the bicipital groove, body of humerus, coracoid process, capsule of shoulder-joint, or tendon of the pectoralis major. The coracoid and glenoid portions of the biceps muscle may fail to unite, being completely separate to their insertion. The long head is occasionally absent, the muscle being uniceps instead of biceps, as in some animals. The *long* or *glenoid head* may not pierce the capsule, but arise from the capsule itself, the humerus, or the great pectoral tendon. The tendon of the biceps sometimes pierces the tendon of the pectoral (see Fig. 2369). This is a very rare anomaly. It is not uncommon in old joints that have become dry from rheumatic disease, to find the long tendon worn through, and per-

haps attached to the groove outside the capsule, or to the head of the humerus, or absent altogether. This pathological condition must not be confounded with the anomaly above described.

The *short* or *coracoid head* may also in rare cases be absent.

The biceps may send a slip of insertion to the coronoid process, capsule of the elbow-joint, or fascia of the forearm. It is sometimes connected with the pronator teres, supinator longus, brachialis anticus, and palmaris longus, by muscular slips. In one case, where the muscular slip crossed the artery and went to the pronator teres, the bicipital fascia was given off from it.

The semilunar fascia is often of larger extent than usual, and may have a high origin. It may be developed into an almost true tendon. It not infrequently sends offshoots to neighboring parts.

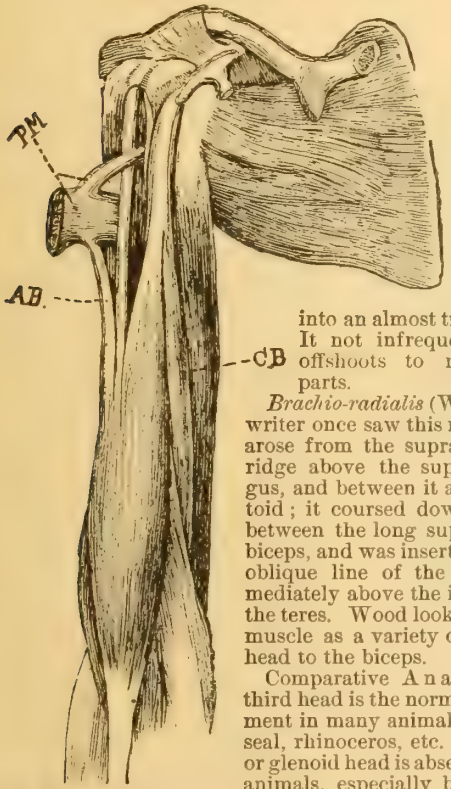

FIG. 2369.—*AB*, third head of biceps, arising from the pectoralis major (*PM*), which is perforated by the long tendon of the biceps; *CB*, coraco-brachialis. (Shepherd.)

Brachio-radialis (Wood). The writer once saw this muscle. It arose from the supra-condyloid ridge above the supinator longus, and between it and the deltoid; it coursed down the arm between the long supinator and biceps, and was inserted into the oblique line of the radius immediately above the insertion of the teres. Wood looks upon this muscle as a variety of a fourth head to the biceps.

Comparative Anatomy: A third head is the normal arrangement in many animals, *e.g.*, bat, seal, rhinoceros, etc. The long or glenoid head is absent in many animals, especially birds. The short or coracoid head is not present in many animals, as the seal, porcupine, paca, and the carnivora, as the dog, cat, bear, hyena, etc. The glenoid head in these comprises the whole muscle. In some, as the American bear, the coracoid head is represented by a very thin tendinous strand.

Brachialis Anticus. Subject to frequent variations. It may be divided into two or three portions. On one occasion the writer saw a slip arise in common with the outer head of the triceps, and after ending in a round tendon, join the brachialis anticus near the coronoid process. The muscle may be inserted into the capsule of the elbow-joint, radius, bicipital fascia, or fascia of the forearm; it may be connected with neighboring muscles, as the biceps, deltoid, coraco-brachialis, pronator teres, or supinator longus. All these varieties have been seen by the writer. When there is a continuity of this muscle with the supinator longus it simulates a normal condition which exists in apes and monkeys, assisting them in twisting their bodies when hanging by their anterior extremities.

Triceps Extensor Cubiti. This is one of the most constant muscles in the body as to its insertion. One of the most common varieties is a fourth head arising from the inner side of the humerus. This fourth head may come from the axillary border of the scapula. The scapular head may have a more extensive origin than usual. The writer once saw a strong muscular slip, continuous with the deltoid and separated by a bursa from the teres minor, have a tendinous insertion into the scapular head near its origin. In some animals, as the American black bear, the scapular head is of huge size, and arises from the whole axillary border of the scapula.

Gruber, Macalister, and Testut each report a case of a slip going from the coracoid process and capsule of the shoulder-joint to the triceps. In one instance the writer saw a fleshy slip between the triceps and teres major.

Dorso-epitrochlearis (accessorius tricipites). Occasionally the muscle to which the above name is given, and which is common in quadrumana and other animals, is seen in man. It has already been described with the latissimus dorsi.

Epitrochleo-anconeus. Exists frequently in man. Gruber found it in 1 in 3; Macalister, 1 in 4; and Wood, 1 in 17. It is triangular in shape, the apex being attached to the back of the internal condyle and the base to the olecranon process. The ulnar nerve passes beneath it and supplies it (see Fig. 2370). This muscle is exceedingly common in mammals. According to Galton, it is universally present in the edentata, less frequent among the primates, disappears among the anthropoid apes, and emerges again occasionally in man as an anomaly. Mr. Galton considers that it, like the supracondyloid process, is now "an almost functionally useless heirloom, which has descended to us from remote ancestors." Mr. J. B. Sutton (*Jour. of Anat. and Phys.*, April, 1885) says that when the epitrochleo-anconeus is not represented as a muscle, its place is occupied by a collection of fibrous tissue having the exact shape and attachments of the muscle, and forming a bridge under which goes the ulnar nerve.

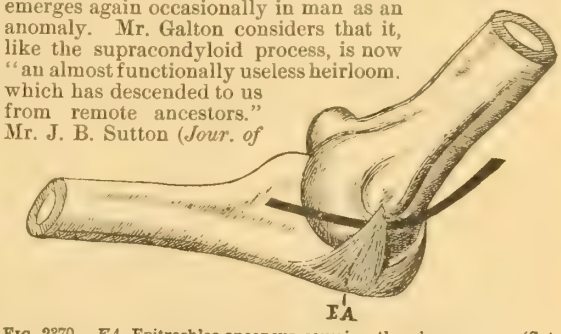

FIG. 2370.—*EA*, Epitrochleo-anconeus covering the ulnar nerve. (Sutton.)

Subanconeus. This consists of a few muscular fibres, which are seen on removing the triceps from the lower part of the humerus; they extend from the lower end of the humerus to the capsule of the elbow-joint. It is homologous with the subcrureus muscle found in the lower limb beneath the quadriceps extensor. It is looked upon by many anatomists as a dependent of the triceps.

Anconeus. May vary as to the closeness of its connection with the triceps or extensor carpi ulnaris.

Pronator Radii Teres. The coronoid head is sometimes wanting, in most animals it does not exist. Occasionally there is a third head which arises from the internal intermuscular septum, or from a supracondyloid process when that variation is present; in such cases the direction of the brachial artery is often changed.

Sometimes the third, or supernumerary head, arises from the tendon of the biceps or brachialis anticus. The pronator teres may have its insertion lower down the radius than usual. It may also be divided into two portions, as in birds. The coronoid portion may be separated entirely from the condyloid, or there may be a doubling of each of these portions.

The pronator teres may be connected with the palmaris longus, carpi radialis flexor, or sublimis digitorum in the forearm and the biceps, brachialis anticus, and coraco-brachialis in the arm.

Flexor Carpi Radialis. It may receive an additional slip of origin from the biceps tendon and fascia, the coronoid process, or the radius. It may have an inser-

tion partly into the annular ligament, trapezium, scaphoid, or fourth metacarpal bone

Palmaris Longus. This is one of the most variable muscles in the body. It is absent in about ten per cent. of individuals, and in rare cases is only represented by a tendinous band. It does not exist in the solipeds, ruminants, or pachyderms. The form varies considerably. There may be a central fleshy portion, with a long, slender tendon at each end; the muscular portion may be at the distal end. It has been seen muscular throughout, and again has been seen to consist of two bellies united by tendon. The palmaris longus is occasionally double; when a second muscle exists it generally arises by tendon, or is connected with the carpi ulnaris, or sublimis digitorum muscle. It may arise from the intermuscular septum between the two last-mentioned muscles, by a tendinous origin, and continue as part of the ulnaris as far as the middle of the forearm, then form a large belly which ends in a tendon near the wrist. The writer has seen it furnish the origin of the flexor brevis minimi digiti; a somewhat similar arrangement exists in the cebus and magot. Occasionally it receives an additional slip of origin from the coronoid process or radius. It sometimes terminates variously—in the fascia of the forearm, muscles of the little finger, annular ligament, scaphoid and pisiform bones, and tendon of the flexor carpi ulnaris. The writer once saw the tendon of this muscle near the wrist give off a broad muscular slip, which was inserted into the base of the first phalanx of the little finger. Most of the anomalies of this muscle correspond to the normal arrangement in some of the lower animals.

Flexor Carpi Ulnaris. Is frequently inserted into the fifth metacarpal bone. It has been seen sending a slip of insertion to the fourth metacarpal. It sometimes gives off a slip to the annular ligament, but this is regarded as a supernumerary palmaris longus, as are also those cases where a separate portion from the epicondyle passes down to be inserted into the pisiform bone. It is in rare cases double.

Flexor Sublimis Digitorum. The radial origin of this muscle is sometimes wanting. The muscle is occasionally subdivided, each of the tendons being connected with a separate fleshy belly. This is more common with the index and little fingers, and may be classed among the anomalies called progressive. The tendon to the little finger may be absent, or the superficial flexor may be connected by slips with the deep flexor and the long flexor of the thumb. This is the arrangement in most mammals, and in man, and his order only, is seen the marked differentiation of the flexors. One of the lumbrical muscles occasionally arises from the sublimis digitorum. This muscle may send a muscular slip to the annular ligament and palmar fascia; this is the arrangement in the bear, and is supposed to represent the palmaris longus.

Flexor Profundus Digitorum. In many animals this muscle is intimately blended with the foregoing, but in man is generally quite distinct; not infrequently, however, it is connected with the sublimis digitorum and also with the flexor pollicis. It occasionally has an additional origin from the internal condyle and coronoid process (the *accessorius ad flexorem profundum* of Gantzer), which may join any one of the perforating tendons, commonly those going to the index and middle fingers (Wood). This is the normal arrangement in many mammals. The writer saw this coronoid slip very well developed on both sides of a negro subject. He also, some years ago, found a strange variety of the *accessorius* muscle occurring on both sides of the same subject. The muscle arose from both the internal condyle and inner side of the coronoid by fleshy fibres, developed into a large muscular belly which divided into two portions, each ending in a tendon, the innermost going to the terminal phalanx of the little finger, and the outermost to the terminal phalanx of the index, superficial to the tendon of the sublimis. On both sides, near the origin of this accessory muscle, a large slip went to the profundus digitorum.

The profundus digitorum may have an origin from the radius; when this occurs it joins the indicial portion of the muscle.

Flexor Indicis. The indicial portion of the profundus may be quite distinct from the rest of the muscle. In one case the writer saw it connected with the flexor longus pollicis by a tendinous intersection. A flexor indicis is found in the gorilla and chimpanzee.

The tendon to the little and middle fingers may also be quite separate and distinct from the rest of the profundus. Accessory slips are not infrequently found going to join the various tendons of the muscle.

Lumbricales. Varieties of these muscles are common; they may be diminished in number to three, or increased to five or six. Two may be inserted into one finger, or one into two by the bifurcation of a muscle. Occasionally the perforating tendons of the fourth and fifth fingers are furnished by lumbrical muscles. The third muscle is more frequently abnormal than the others. The writer has seen the lumbrical muscle of the little finger arise in the middle of the forearm from the sublimis digitorum by a round tendon, this, after passing under the annular ligament, developed a large fleshy belly which was inserted into the fifth finger. This might be regarded as a case of absence of the fourth lumbrical muscle, its place being taken by a slip from the sublimis.

Fig. 2371. — The pronator quadratus, *PQ*, consisting of two triangular portions with bases reversed. (Fenwick.)

Flexor Longus Pollicis. Has frequently a slip of origin from the coronoid process and internal condyle. This slip has been seen to pierce the radial nerve. The muscle may be connected by a slip with the superficial and deep flexors, and also with the pronator teres. It is sometimes fused with the profundus digitorum so as to form a single muscle, as is the case in nearly all mammals. It is sometimes fused with the indicial portion of the profundus, when that part forms a distinct flexor indicis, as in the gorilla. It has been observed sending a slip to the index-finger and also to the first lumbricalis.

Pronator Quadratus. The pronator quadratus is sometimes entirely wanting; it may consist of two, three, and even four layers crossing each other. The attachment to the bones of the forearm may be greater than usual. It occasionally sends a muscular slip from its ulnar or radial attachment to the carpus. It may consist of two distinct triangular portions with the bases reversed; the anterior arising from the ulna by aponeurotic fibres and inserted into the radius by fleshy fibres, the deeper and inferior portion inserted into the ulna by fleshy fibres, and arising by aponeurosis from the radius (Fenwick, Sappey, and Macalister). (See Fig. 2371.)

The muscle may consist of a single triangle, as in some animals, *e.g.*, the macaque, seal, etc.

Flexor Carpi Radialis Brevis (Wood) (Radio-carpus of Fano). This is a small muscle occasionally seen. It arises from the anterior surface of the radius below the oblique line, and is inserted into the annular ligament, trapezium, os magnum, or other part of the carpus. It may also be inserted into one of the metacarpal bones. A variety of this muscle is, in rare cases, seen arising from the ulna (ulno-carpus).

Supinator Longus. The varieties of this muscle are few in number. It sometimes has a higher attachment to the humerus than usual, and its insertion into the styloid process may be extended upward along the radius. The

writer once saw a slip from the supinator attached to the middle of the outer border of the shaft of the radius.

The tendon of the supinator may be divided into two or three slips. In cases of absence of the radius this muscle is wanting.

Occasionally it is double the accessory portion (*brachio-radialis*), arising with it and being inserted into the radius in the neighborhood of the oblique line. It not infrequently is connected with neighboring muscles, viz., the deltoid, brachialis anticus (as in monkeys), flexor carpi radialis longior, and the abductor pollicis. The tendon may be pierced by the radial nerve.

Extensor Carpi Radialis Longior et Brevior. These muscles are sometimes completely fused. In many mammals (horse, pig, etc.) they form a single muscle, which ends in two tendons. In man the fusion may be only partial. The tendons of one or other of the muscles may be subdivided. The *radialis longior* may have an additional insertion into the second or third metacarpal bone. Wood has described a muscle which he calls the *extensor carpi radialis accessorius*. It arises from the humerus below the *radialis longior*, and is inserted into the first metacarpal bone, first dorsal interosseous muscle, abductor, or short flexor of the thumb. The writer has seen a digastric slip given off from the extensor carpi radialis longior, which joined the abductor pollicis. Testut has described an *abducteur huméral du pouce*, arising from the external condyle, and inserted into the first phalanx of the thumb. The long extensor is occasionally united with the supinator longus. Macalister has recorded absence of the short extensor.

Extensor Communis Digitorum. The varieties of this muscle relate chiefly to the increase or diminution of the tendons of insertion. The tendon going to the little finger may be absent, and also that going to the index finger. It is more common to have an increase than a diminution of tendons. Any one of the tendons may be subdivided, and as many as eleven have been observed by Perrin and Rüdinger, due to doubling of some tendons and tripling of others. Curnow in one case saw twelve tendons go to the inner four digits and five to the thumb, making seventeen in all. Five and six are commonly seen, the tendons of the little and index-fingers being most often duplicated. The extensor communis occasionally sends a slip to the thumb.

The indicial portion of the muscle may be completely separated from the rest, and the extensor minimi digiti may be inseparably connected with the larger muscle.

Extensor Minimi Digiti. Sometimes fused with the common extensor or carpi ulnaris. It may be double, the additional tendon being inserted into the ring-finger. It may have an ulnar attachment, and may be inserted into the annular ligament. Complete absence of the muscle has been observed.

Extensor Carpi Ulnaris. An accessory or short extensor, going from the lower end of the fourth and fifth metacarpal bone, has been described. The tendon is not unfrequently prolonged downward to the first phalanx of the little finger (*ulnaris quinti*). It is also frequently connected with the abductor minimi digiti. Sir William Turner has lately reported a case of absence of this muscle; its place was taken by a slender band of fibrous tissue. Curnow has also recorded absence of this muscle.

Supinator Brevis. An accessory supinator brevis has been observed going from the external condyle of the humerus to the radius or ulna. The extent of attachment to the radius may be much greater than usual. A sesamoid bone is sometimes found in the tendon of the muscle. This occurs normally in some animals, and is also seen in the popliteus, of which the short supinator is supposed to be the homologue.

Extensor Ossis Metacarpi Pollicis. The tendon of this muscle is frequently double, and sometimes is triple. When double, usually both are inserted into the metacarpal bone, or one into this bone and the other into the trapezium, as is the normal arrangement in apes. The supernumerary tendon may be inserted into one of the short muscles of the thumb. The muscle may be double throughout, and Curnow has in one case seen it triple.

Extensor Primi Internodii Pollicis. Is sometimes absent, or is not differentiated from the extensor ossis metacarpi. Curnow describes a case of doubling of this muscle. It is found only in man.

Extensor Secundi Internodii Pollicis. Doubling of the muscles is not uncommon. Additional muscles are occasionally present, and have been described by Curnow (*Jour. Anat. and Phys.*, vol. x., p. 596).

Extensor Primi Internodii Pollicis et Indicis. In some rare cases, there is an accessory extensor present, which arises between the extensor indicis and the extensor secundi internodii pollicis; it divides into two tendons, one of which goes to the first phalanx of the thumb, and the other to the index-finger. This muscle exists normally in the dog and many other carnivora.

Extensor Indicis. The tendon of this muscle is frequently divided into two portions, one going to each side of the index-finger; sometimes one of the tendons goes to the middle finger. This latter is occasionally seen as a distinct muscle (*extensor proprius digiti medii*). It arises from the lower part of the ulna or posterior ligament of the wrist-joint, and is inserted into the base of the first phalanx of the middle finger. It exists normally in apes.

A short *extensor indicis* is occasionally seen taking its origin below the long extensor, from the back of the wrist or a carpal bone; it is inserted with the long extensor into the index-finger. The writer has seen this accessory muscle arise from the radius, and pass through a separate compartment in the annular ligament to be inserted into the index-finger. The extensor indicis may have a more extensive attachment to the radius than usual. The writer has seen it connected by a tendinous slip with the extensor secundi pollicis. Curnow describes one case where the muscle divided into three tendons — one inserted normally, one with the secundi internodii, and one with the aponeurosis over the middle finger. A somewhat similar arrangement is seen in the hedge-hog, kangaroo, and manis. It is rarely absent.

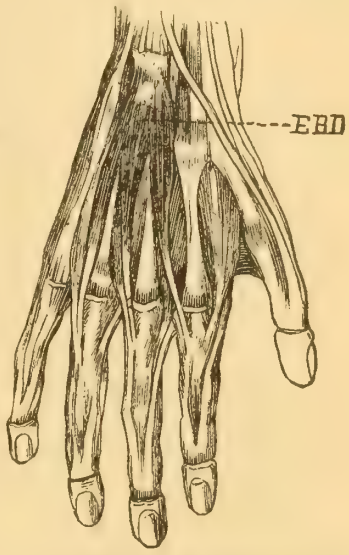

Fig. 2372.—*EBD*, extensor brevis digitorum. (After Wood.)

Extensor Pollicis and Indicis (see above).

Extensor Brevis Digitorum. Very rarely met with. It arises from the back of the wrist, post-annular ligament, from the carpus itself, or the bases of some of the metacarpal bones by fleshy fibres; it sends tendinous slips to one, two, or three fingers. The writer has seen them going to the ring- and index-fingers and to the middle finger. It is probable that the extensor brevis indicis and extensor medii digiti are varieties of this muscle. (See Fig. 2372.)

This muscle is common in reptiles, and only survives in a few anomalous mammals of the order Edentata (Curnow).

Muscles of the Hand.— *Palmaris Brevis.* Varies considerably as to its degree of development. It is occasionally altogether wanting.

Abductor Pollicis. Some anatomists describe the muscle as normally consisting of two portions—an outer and inner. It may receive a third belly from the opponens pollicis, or be connected with it by a muscular slip. It may also receive an accessory slip from the extensor carpi radialis longior, ossis metacarpi pollicis, palmaris longus, or from the radius. Not infrequently a thin, muscular

slip is seen going from the skin of the ball of the thumb opposite the tuberosity of the trapezium to the abductor pollicis. Some regard this latter as a skin muscle.

Flexor Brevis Pollicis. The deeper belly of the muscle is often with difficulty differentiated from the adductor pollicis.

Adductor Pollicis. This muscle is frequently blended with the deep portion of the short flexor of the thumb.

Abductor Minimi Digiti. Sometimes divided into two or even three slips. It is often united with the flexor brevis minimi digiti. It may have an accessory slip, arising from the tendon of the ulnar flexor, the annular ligament, fascia of the forearm, and tendon of the palmaris longus. The writer has seen an accessory head arise from the intermuscular fascia beneath the flexor radialis and ulnaris. The accessory slip may pass down, and cover the ulnar artery.

Flexor Brevis Minimi Digiti. May be absent or replaced by a slip from the abductor minimi digiti or opponens. An accessory head may spring from the lower third of the inner border of the ulna, from the carpi ulnaris, or fascia of the forearm. A doubling of the muscle has been observed.

Opponens Minimi Digiti. May be closely connected with neighboring muscles, or receive a second head from the fascia of the forearm (Henle).

M. Pisi-uncinatus. This is a muscle described by Calori, and stretches between the pisiform bone and unciform process of the unciform bone.

Interossei. These muscles do not vary to any great extent. They may be double in one or two interrosseous spaces. Henle describes a *palmar interosseous* muscle of the thumb as normal. It arises from the metacarpal bone of the thumb, and joins the inner head of the flexor brevis pollicis. The arrangement of the interosseous muscles of the hand has been observed, in rare cases, to be similar to that of the foot.

Accessory Palmar Abductor Indicis. The writer once saw a small muscle arising from the third metacarpal bone, beneath the adductor pollicis and inner head of the flexor brevis pollicis. After ending in a round tendon, it was inserted into the base of the first phalanx of the index-finger.

Muscles of the Lower Limb.—*Gluteus Maximus.* The great size of this muscle is peculiar to man, principally on account of his erect position. In the human species the muscle always covers the ischial tuberosity; in apes, this is uncovered. The variations are important. The muscle may be considerably reduced in size. Macalister reports a case where the muscle was attached above to the last two sacral vertebræ only. The superficial portion of the muscle is often separated from the deep by a layer of cellular tissue. The lower edge of the muscle is sometimes quite distinct, and represents the *agitator caudæ* of the lower animals; it may be inserted into the femur or the femoral aponeurosis. The gluteus maximus is occasionally blended with the tensor fasciæ, as in the elephant and some monkeys.

Ischio-femoral. The writer has only once seen this muscle. It arose from the inner edge of the great tuberosity by a round tendon, which soon developed into a triangular-shaped muscle of considerable size; it was separated from the gluteus maximus by the great tuberosity, and joined it near the femur. It was inserted into the lower end of the gluteal ridge of the femur. The *ischio-femoral* muscle exists normally in the gorilla, certain apes, and other animals.

Gluteus Medius. The deeper fibres of this muscle may end in a separate tendon, which is attached to the upper border of the great trochanter. Its upper or lower border may be separated from the rest of the muscle. Occasionally a bursa is interposed between the tendon of the gluteus medius and the pyriformis. Some of its fibres may be inserted into the pyriformis, or its posterior border may be completely fused with that muscle.

Gluteus Minimus. Occasionally divided into anterior and posterior portions; may send slips to the hip-joint, to the pyriformis, gemelli, or vastus externus muscles.

Accessory Gluteus Minimus (fourth gluteal; scansorius). The fibres of the anterior border are in some cases separated from the muscle, and inserted variously into the anterior border of the great trochanter, into the capsule, or near the lesser trochanter, where it is connected with the iliacus tendon. It represents the scansorius muscle of apes. Testut looks upon it as representing the extra pelvic portion of the iliacus muscle.

Tensor Vaginæ Femoris (tensor fasciæ). Varies but little. May have a supernumerary origin from the abdominal fascia, iliac crest, and Poupart's ligament. It is sometimes fused with the gluteus maximus. A duplication of the muscle has been observed by Macalister and Testut.

Pyriformis. The most common variation of this muscle is its division into two portions by the great sciatic nerve or its external popliteal branch. It is occasionally fused with the gluteus medius more or less completely. It may be connected with the gluteus minimus by a few fibres. Its tendon is sometimes united with that of the obturator internus, or receives the gemellus superior. It may have its origin from as many as five sacral vertebræ, or as few as one. It frequently has no attachment to the first sacral vertebra. It may be inserted into the capsule of the hip-joint. Its complete absence has been noted by several observers.

Obturator Internus. The variations of this muscle are unimportant. It may receive supernumerary fasciculi from various parts in the pelvis, as the psoas minor muscle, ischial tuberosity, sacro-sciatic ligaments, third sacral vertebra, pubes, etc. A pubic portion is sometimes separated by the obturator nerve.

Obturator Externus. Wood has described a large fleshy slip going from the adductor brevis to join the tendon of this muscle, and Macalister has noted a separation of a pubic fasciculus by the obturator nerve.

Gemelli. The *superior gemellus* is not infrequently absent, or very small in size. The *inferior gemellus* has also been observed absent, but more rarely. Doubling of the *superior* has been noticed; it has also been seen fused with the pyriformis and gluteus minimus. The gemellus inferior and quadratus femoris are frequently inseparably united to the obturator internus.

Quadratus Femoris. This muscle may be much reduced in size, or absent altogether; in such a case, the inferior gemellus is larger. It has been described as sometimes double. It may be united above with the gemellus inferior, and below with the adductor magnus.

Biceps Flexor Cruris. The two heads may be quite separate, as in the orang and chimpanzee. The short head may be divided into several fasciculi, or, in rare cases, absent altogether. This latter arrangement is the usual one in a large number of mammals. There is sometimes a third head, which may arise from the femur, from the ischial tuberosity, coccyx, sacrum, fascia lata, or gluteal fascia. The third head generally joins the long head, though when it arises from the linea aspera, or inner condyloid ridge, it joins the short head. The third head has been looked upon as homologous with the caudal origin of the biceps in the lower animals. In rare cases a slip (*ischio-calcaneus*) has been seen going from the long head to the gastrocnemius, external tuberosity of the tibia, femoral aponeurosis, and even to the tendo-achillis. This arrangement is a modification of that seen in the lower animals, especially the bear.

Semitendinosus and *Semimembranosus.* These two muscles may be fused into one. The *semimembranosus* may be absent altogether. It has been seen double. Occasionally, it derives its origin for the most part from the great sacro-sciatic ligament.

The *semitendinosus* may have a supernumerary origin from the coccyx, and sometimes gives off a muscular slip about its middle, which is inserted into the fascia of the leg. This arrangement is normal in some of the lower animals.

Psoas Magnus. Varies somewhat in volume, according as its origin is more or less extensive. It occasionally forms a muscle quite distinct from the iliacus. It may be divided into two portions, between which passes the anterior crural nerve. This is merely an exaggeration of the normal condition. An accessory psoas is some-

times seen arising from the transverse processes of some of the lumbar vertebræ. The writer, in a male subject, saw this accessory psoas of considerable size; it arose from the transverse process of the fourth lumbar, and as it descended widened out into a broad muscle, which joined the magnus in the middle of the iliac fossa.

Psoas Parvus. Frequently absent and occasionally fused with the magnus. It usually arises from the bodies of the last dorsal and first lumbar vertebræ, and soon becomes tendinous; it then passes down to the inner side of the magnus, and ends by being inserted into the iliopectineal line and pectineal eminence. It has been noted as having an insertion into the lesser trochanter, as in the seal, guinea-pig, etc.

Although inconstant in man, it is a large, well-developed, and constant muscle in the lower animals. Gruber in 450 subjects found absence of this muscle on both sides in 183, and on one side in 69; Perrin in 112 subjects found it present in only 32; Theile found it in only 1 out of 20 subjects examined; and Testut, 6 out of 32.

It is occasionally double.

Iliacus. May be divided into several distinct portions. The deep portion is not infrequently separated from the superficial by a well-marked cellular interval, and thus constitutes a separate muscle.

Superficial Iliacus. Sometimes seen arising from the crest of the ilium, last lumbar vertebra, or upper border of the sacrum. In one subject, the writer saw this mus-

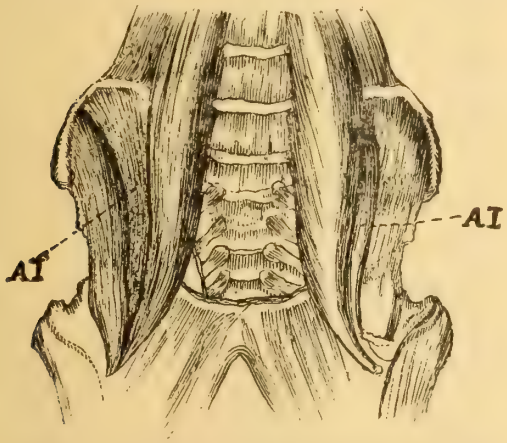

FIG. 2373.—*AI, AI,* examples of double superficial iliacus muscles.

cle on both sides: on the right side it was a broad, flat muscle, arising from the posterior third of the crest of the ilium, and on the left a fusiform muscle, which arose from the body of the last lumbar vertebra and upper border of the sacrum. Both muscles ended in strong tendons, which were pierced by the anterior crural nerve, and joined the iliacus below Poupart's ligament (Fig. 2373).

Ilio-capsularis vel Iliacus Minor. Arises from the anterior inferior spine of the ilium and capsule of the hip-joint; it may be inserted into the lower part of the anterior intertrochanteric line, lesser trochanter, or iliofemoral ligament. In one subject the writer saw a well-marked bursa separating it from the iliacus.

Sartorius. A case of absence of this muscle has been reported by Meckel. It is occasionally double in its whole course. An accessory portion has been seen having an insertion into the femur, patella, or tendon of the normal muscle.

The sartorius, in addition to its tibial attachment, may have an insertion into the femoral aponeurosis, the capsule of the knee-joint, or the femur itself in the neighborhood of the internal condyle. All these various insertions are seen normally in mammalia. A tendinous inscription, in rare cases, is seen in this muscle. The writer has only once met with this anomaly.

Quadriceps Extensor Cruris. Not subject to many variations. Occasionally the acetabular origin of the *rectus* is wanting, or it may be reinforced by an additional origin from the anterior superior spine. The *vasti* muscles may be divided into two portions, superficial and deep; this bilaminar arrangement is the normal one in many birds. The two vasti muscles are often closely united.

The *Subcrureus* is a muscle which is very variable in volume. It is often divided into two or more separate muscular bundles.

Accessory Head to Quadriceps. The writer once saw, on the left side of a male subject, a supernumerary muscle which arose by a double tendinous origin from the anterior portion of the capsule of the hip-joint and the anterior border of the great trochanter. The two tendons soon united to form one strong tendon, which passed down the thigh between the iliacus and tensor fasciæ, lying on the vastus externus; about the middle of the thigh it developed into a strong muscular belly three inches long. After passing beneath the rectus it joined the common tendon of the quadriceps.

Gracilis. The variations are unimportant and consist chiefly of a greater or less extent of origin and insertion. An accessory head is sometimes seen.

Pectineus. May be occasionally divided into two portions, as in some of the lower animals, each portion supplied by a different nerve—the inner by the obturator, and the outer by the anterior crural. In one case the writer saw it divided into a superficial and deep portion; the superficial arose from the pectineal line, two inches outside the pubic spine, and was inserted into the linea aspera, with the adductor magnus. The deep portion was the normal muscle.

The pectineus is not infrequently united with the adductor longus; this occurs normally among the rodentia, carnivora, and quadrumana. It may be sometimes inserted into the capsule of the hip-joint.

Adductor Longus. May be divided into two portions by the passage of blood-vessels. It is often inserted low down on the femur, and its tendon is inseparable from the magnus. It is sometimes fused with the pectineus.

Adductor Brevis. Occasionally divided into two or three portions—may be continuous with the magnus. It has been reported as united to the tendon of the obturator externus.

Adductor Magnus. The upper part of this muscle is so often separated from the main portion that Henle, Macalister, and other anatomists describe it under the name *adductor minimus* or *quadratus.* Its upper border is occasionally completely united with the quadratus femoris. The different parts of the muscle are not infrequently separated; the portion inserted into the internal condyle is frequently quite distinct (*ischio-condyloid*).

Tibialis Anticus. This muscle has been seen arising from the femur, as occurs so generally in the higher mammals. In the case reported the leg was congenitally deformed. The tendon is occasionally double, the extra tendon being inserted into the astragalus or base of the first metatarsal, as in apes. The tendon has been seen divided into three portions, and occasionally a sesamoid bone is formed in it.

Tibio-fascialis Anticus. A small muscle described by Wood, Macalister, and Humphry, which arises from the lower third of the anterior edge of the tibia, over the tibialis anticus, and is inserted into the annular ligament and deep fascia. It is sometimes represented by a tendinous slip from the tibialis anticus, which is inserted into the fascia of the dorsum of the foot. Gruber describes a *tibio-astragalus anticus* arising from the tibia and interosseous ligament behind the tibialis anticus, and inserted in the neck of the astragalus.

Extensor Proprius Hallucis. Is occasionally united with the extensor communis digitorum, or short extensor of the toes. The muscle or its tendons may be double, and have a supernumerary insertion into the metatarsal bone or first phalanx of great toe. It is sometimes inserted into the second toe. Its tendon may be divided into three portions (*extensor hallucis longus tricaudatus.*)

Extensor Ossis Metatarsi Hallucis is a small muscle arising from the extensor hallucis, tibialis anticus, extensor communis digitorum, or as a separate muscle close to the

extensor hallucis, going through the same compartment in the annular ligament as the hallucis; it is inserted into the metatarsal bone of the great toe.

Extensor Primi Internodii Hallucis. In one-half the subjects examined Professor Wood found this muscle; it is generally an offshoot from the extensor hallucis, but sometimes arises separately.

Extensor Longus Digitorum Pedis. Varies considerably in the mode of origin and the arrangement of its tendons. The number of tendons may be increased by the doubling of any one. It is not uncommon for the tendon going to one toe to give slips to adjacent toes. It may have an additional insertion into the metatarsus. Occasionally a supernumerary tendon is seen going to the great toe. The tendons may be united on the dorsum by slips, as in the hand. It may be united to a greater or less extent with the extensor proprius hallucis, or extensor brevis digitorum. Each of the tendons may have a separate muscular belly in connection with it. Wood reports a case where the four tendons had each a separate muscular belly. All these abnormal arrangements have their corresponding normal conditions in the lower animals.

Peroneus Tertius. Sometimes of large size, and occasionally inserted entirely into the fourth metatarsal bone. Its tendon may unite with that of the extensor going to the fourth or fifth toe, or it may unite with the fourth dorsal interosseous. The muscle may be absent altogether or be double.

Peroneus Longus. Occasionally fused with the brevis. In one case it has been noted as arising from the femur, as in many lower animals, *e.g.*, the bear, hyæna, etc. It may have a supernumerary insertion into one of the metatarsal or cuneiform bones, as occurs in some animals. The tendon sometimes gives origin to the flexor brevis minimi digiti and outermost plantar interosseous (Wood).

Peroneus Accessorius. This is a small muscle which arises from the fibula between the peroneus longus and peroneus brevis, and ends in a tendon which joins the long peroneal.

Peroneus Brevis. The tendon of this muscle is occasionally divided into two portions, the supernumerary one going to the fourth metatarsal or cuboid bone, or to the proximal phalanx of the fifth toe, joining the extensor tendon of that toe. It may also be inserted into the abductor minimi digiti.

Peroneus Quinti Digiti. It arises from the fibula beneath the peroneus brevis, and is inserted into the extensor aponeurosis of the little toe. It is seldom seen as a distinct muscle, being generally united with the peroneus brevis. It is seen normally in some animals, as the bear and the cat.

Peroneus Quartus. A muscle which is not infrequently seen arising from the back of the fibula, between the peroneus brevis and flexor hallucis, or from the fascia of the deep muscles of the calf; it is inserted into the external malleolus, peroneal tubercle of the os calcis, or the ridges of the cuboid groove. This is looked upon by Testut as a variety of the peroneus quinti digiti.

In a male subject the writer saw, on both sides, the peroneus longus divided into two portions; the outer and larger passed down in the usual course of the long muscle, but the inner and smaller portion, which arose principally from the intermuscular septum, ended in a tendon which passed through the same compartment in the annular ligament as the outer portion, and immediately before it reached the peroneal tubercle it divided into two parts, one of which spread out and was inserted into the tubercle; the other crossed over the tendon of the peroneus brevis and was lost in the fascia covering the dorsum of the foot; between these two tendons passed the tendon of the peroneus brevis. This was probably a variety of the peroneus quinti digiti and peroneus quartus muscles.

Extensor Brevis Digitorum. The number and arrangement of the tendons vary considerably. Very frequently one or more of the tendons are doubled. A slip not infrequently goes to the little toe. The number of tendons may be reduced to two; occasionally a single tendon may have two muscular heads in connection with it. The innermost portion going to the great toe is often separated from the rest of the muscles, and is called the *extensor brevis hallucis.* Wood describes cases where slips from the tendons of the extensor brevis joined the dorsal interosseous. There may be a special slip going to the second metatarsal bone or long extensor tendon of the second toe. This would be the homologue of the extensor indicis of the hand.

FIG. 2374.—*A*, example of a third head to the gastrocnemius. (Wood.)

Gastrocnemius. The two bellies are sometimes more or less completely separated from each other, as in the marmot, unau, coati, etc. The most common anomaly is the existence of a third head (see Fig. 2374). This consists of a band of muscular fibres, which may arise from either condyloid ridge, the popliteal surface of the femur, or the posterior ligament of the knee-joint; passing down, it most frequently joins on the united muscle. This third head may pass between the popliteal artery and vein, or over both vessels and nerves. It is sometimes divided into two portions.

A slip may be given off from the biceps, semi-tendinosus, or adductor magnus to the gastrocnemius. The writer, in one female subject, saw complete absence of the external head. On removing the skin and fat, the first structure which came into view was the plantaris muscle (see Fig. 2375). Absence of the whole muscle has been observed.

Occasionally a sesamoid bone is developed in the tendon of the external head. A similar arrangement exists in many animals.

Soleus. An accessory soleus is occasionally seen which arises from the oblique line of the tibia and joins the inner side of the soleus; it covers the posterior tibial artery, and is often of large size.

The soleus has been observed of very small size, the fibular portion alone existing.

It is sometimes inserted into the os calcis separately from the gastrocnemius, an arrangement which is common in many animals. A muscular slip going from the tibia to the tendinous arch over the popliteal vessels has been occasionally seen.

Plantaris. The plantaris, which is rudimentary in man and gradually disappearing, is of large size in some animals, and in them is continuous with the plantar fascia or flexor brevis digitorum. In man it is frequently absent. It sometimes arises by two heads, the supernumerary one coming from the posterior ligament of the knee-joint or from one of the condyles. The writer has seen this supernumerary head arise from the outer head of the gastrocnemius and the middle of the outer surface of the soleus by a tendinous origin.

FIG. 2375. — Absence of the external head of gastrocnemius. (Shepherd.)

The plantaris has been seen to arise from the popliteal fascia and fibula. The writer on one occasion saw it arise solely from the posterior ligament of the knee-joint. The mode of its insertion varies, its tendon sometimes joins the tendo-Achillis or internal annular ligament, or ends in the deep fascia of the leg. It may send a slip to the plantar fascia (*tensor fasciæ plantaris*). Its tendon may be enclosed in the lower part of the tendo-Achillis.

Popliteus. A sesamoid bone is sometimes developed in

its tendon of origin. The muscle in rare cases is absent altogether.

Popliteus Minor. Is a small muscle, rarely seen, which arises from the femur internal to the plantaris and is inserted into the posterior ligament of the knee-joint. Wagstaffe has described an accessory popliteus which arose from a sesamoid bone developed in the external head of the gastrocnemius, and was inserted into the oblique line of the tibia superficial to the normal muscle (see Fig. 2376).

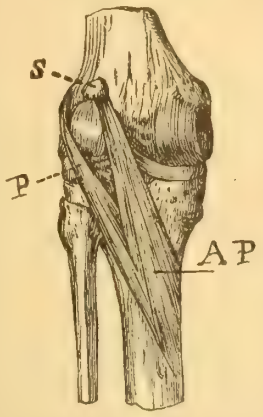

FIG. 2376.—*AP*, accessory popliteus arising from a sesamoid bone (*S*); *P*, normal popliteus. (Wagstaffe.)

Peroneo-tibialis. This is a muscle described by Gruber, who met with it in one in seven subjects. It arises from the inner side of the head of the fibula, and is inserted into the upper end of the oblique line of the tibia. It is placed beneath the popliteus, and is looked upon as the homologue of the pronator teres in the arm. It is seen in many of the lower animals.

Flexor Longus Digitorum Pedis. This muscle varies somewhat as to its origin. It frequently receives extra slips of origin from the deep fascia and aponeurosis of the leg, the tibia, fibula, or flexor hallucis. The writer has several times seen muscular fibres originating extensively from the deep aponeurosis and flexor hallucis, and crossing the tibialis posticus to reach the flexor digitorum. In some cases the tibialis posticus was completely hidden from view by muscular fibres. A similar arrangement is seen in a great many of the apes. The tendon going to the second toe is sometimes absent; in these cases the second toe receives a slip from the flexor hallucis.

Flexor Accessorius Longus Digitorum Pedis. This muscle and its varieties have been described under various names, as *tibio-accessorius*, *accessorius ad accessorium* (Turner); *peroneo-calcaneus internus* (Macalister); *pronator pedis* (Humphry). It may arise from the tibia or fibula by a fleshy belly and in a well-marked tendon, which passes through a separate compartment in the annular ligament, either in front of or behind the flexor hallucis, and finally ending by joining the flexor accessorius or the tendon of the long flexor before it divides. It has been seen to replace the proper accessorius. In its course down to the foot, its fleshy fibres generally cover over the posterior tibial vessels and nerves. When it arises from the fibula and is inserted into the tubercle of the os calcis, it is called the *peroneo-calcaneus internus*, and is looked upon as the homologue of the pronator quadratus of the forearm. The writer has several times seen this muscle arising from the tibia, and only once from the fibula. In one case it arose by two fleshy heads, one from the flexor hallucis, and the other for two inches from the inner border of the tibia immediately below the soleus; the two heads united to form a single belly which, after covering the posterior tibial vessels, ended in a tendon. This tendon passed beneath the annular ligament posterior to the vessels, and in the sole of the foot joined the tendon of the long flexor; the normal accessorius was inserted into this tendon instead of into that of the flexor.

A *flexor proprius digiti secundi*, arising from the tibia and going to the second toe, has been described by Bahnsen.

Flexor Accessorius. The outer head is not infrequently absent. The muscle is sometimes much reduced in size and may even be absent. Its accessory long head has already been described under the name flexor accessorius longus digitorum pedis.

The number of digital tendons to which this muscle can be traced varies considerably. Offsets may be sent to the second, third, and fourth toes, and sometimes to the fifth. In rare cases it can be traced to only two tendons. The muscle has been observed going to the flexor hallucis tendon instead of the digitorum. It sometimes gives off a slip to the fifth toe (as in monkeys), when the slip to that toe from the brevis digitorum is absent.

Lumbricales. Absence of one or more of these muscles occasionally occurs. The writer once saw, on both sides of the same subject, the two outer ones absent. Two are sometimes seen going to one toe. The tendons are frequently inserted into the first phalanges of the toes.

Flexor Hallucis Longus. Seldom varies. The tendons of the digitorum longus and hallucis are seldom completely separated; they are generally united by a slip from the hallucis to the digitorum, and sometimes by one from the digitorum to the hallucis. The slip from the hallucis may generally be traced to the second or third toes, sometimes to all, and sometimes to the second only. In a subject dissected in 1879 by the writer, the tendon of this muscle divided into three tendons, which went to the great, second, and third toes. The longus digitorum divided into four tendons as usual; but those going to the second and third toes were of small size, and joined the ones from the hallucis. The lumbrical muscles were in connection with the digitorum tendons. In this case there was no connection between the tendons of the muscles before division. A slip may be given off from the flexor hallucis in the leg, and after passing under the annular ligament, may join the accessorius. This is a variety of the muscle described above—*flexor accessorius longus digitorum pedis.* In rare cases the tendons of the two long flexors are fused into one, as is seen in the lower animals. The writer once saw a sesamoid bone developed in the tendon of this muscle as it passed over the astragalus and os calcis.

Tibialis Posticus. Very seldom varies. Is occasionally blended more or less intimately with the flexor hallucis. A sesamoid bone is frequently developed in its tendon. It has been described as being inserted into the peroneus longus tendon, second, third, and fourth metatarsal bones, and cuboid. Wood has seen it combine with the flexor brevis hallucis muscles. It has been reported absent by Budge.

Tibialis Secundus. This is a muscle described by Bahnsen, Henle, and Linhart. Henle calls it the tensor of the capsule of the ankle-joint. It arises from the back of the tibia below the flexor digitorum longus, and is inserted into the posterior part of the capsule of the ankle-joint or annular ligament. A similar muscle has been described as being inserted into the anterior part of the capsule of the ankle-joint.

Flexor Brevis Digitorum. The slip going to the fifth toe, which is usually of small size, and very often not perforated by the deep flexor, is sometimes absent altogether. Five tendons have been observed, two going to the second toe. The slip to the little toe, when absent, is occasionally replaced by a small muscle arising from the outer side of the long flexor tendon or flexor accessorius. This arrangement is seen in many of the apes.

The tendons of the short flexor may be united to those of the long flexor, and have a common insertion. Some portion of the short flexor may arise from the long flexor tendon. The writer, a few years ago, saw a very good example of this, an arrangement which is like that which exists in apes. The muscle consisted of two portions, superficial and deep; the superficial arose from the inner tuberosity of the os calcis, and divided into two tendons which went to the second and third toes; the deep portion, however, arose by a fleshy origin from the deep flexor tendon before it was joined by the accessorius; its tendons were distributed to the fourth and fifth toes.

Wood mentions a case where the slip to the fifth toe was augmented by another from the long flexor tendon, they formed a single tendon, which was not perforated but blended with the tendon of the long flexor going to that toe.

Abductor Hallucis. Its tendon is sometimes joined by a muscular slip which comes from the skin in front of the inner ankle. Wood describes a muscular slip from the abductor to the base of the first phalanx of the second toe.

Abductor Minimi Digiti. The tendon is sometimes double.

Abductor Ossis Metatarsi Quinti. A portion of the above has been described, by Wood and Bradley, as a separate muscle arising from the outer tubercle of the os calcis, and inserted into the base of the fifth metatarsal bone; it occurs in about every other subject. Most anatomists look upon this as merely an insertion of the abductor minimi digiti, which fails to exist in about half the subjects examined. Occasionally it exists as quite a separate muscle (see Fig. 2377), having an extensive origin from under the surface of the os calcis. The interest attaching to this muscle lies in the fact that it is the true homologue of a muscle always present in the anthropoid apes.

FIG. 2377. *A.Q*, Example of the abductor ossis metatarsi quinti arising from os calcis. (Bradley.)

Flexor Brevis Hallucis. A slip may be sent to the base of the first phalanx of the second toe (Wood). It sometimes receives fibres of origin from the os calcis or long plantar ligament. Occasionally it fails to be attached to the cuboid.

Adductor Hallucis. Occasionally a slip is seen going to the base of the first phalanx of the second toe; this may arise from the second metatarsal bone, or sheath of the tendon of the peroneus longus. Henle thinks it represents the *interosseus volaris primus* of the hand.

Opponens Hallucis (Macalister). Given off from the preceding muscle and inserted into the base of the metatarsal bone of the great toe, as in apes.

Adductor Indicis. The writer once saw a large muscle arise from the cuboid, and sheath of the peroneus longus tendon, outside the adductor hallucis, and go to be inserted into the base of the first phalanx of the second toe. This, no doubt, is the homologue of the adductor indicis of quadrumana and other animals, as the sloth, elephant, etc.

Transversus Pedis. The slip from the fifth toe is often wanting, and others may also be absent. The whole muscle is occasionally absent.

Superficial Transversus Pedis. In 1879 the writer saw, in the right foot of a male subject, immediately beneath the skin, a muscle which arose from the bases of the first phalanges of the second, third, and fifth toes, and was inserted into the base of the first phalanx of the great toe; deeper down the normal transversus pedis existed and was of the usual size.

Flexor Brevis Minimi Digiti. A slip of muscle is very frequently seen given off from the inner border of this muscle, and inserted separately into the anterior half of the lateral border of the fifth metatarsal bone. In some cases it is almost a distinct muscle. Henle calls it the *opponens minimi digiti*, and looks upon it as the normal arrangement. It is well developed in the orang-outang.

Interosseous. Seldom abnormal. May vary sometimes in size, according to the size and use of corresponding digit (Wood). A slip is occasionally seen arising from the base of the second metatarsal bone and sheath of the peroneus longus, and inserted into the base of the first phalanx of the second toe. Henle regards this as the homologue of the interosseus volaris primus of the hand.

MUSCLES OF THE TRUNK.—*Serratus Posticus Inferior.* Macalister has observed absence of this muscle. It may consist of only three slips, or in rare cases there may be as many as five or six from the first to the sixth rib. Slips may be received from the levator anguli scapulæ. I have, in two cases, seen a well-developed muscular slip arising from the mastoid process, beneath the sterno-mastoid, and inserted into the upper border of the serratus posticus superior. Once I noted a slip passing from the fifth cervical transverse process to this muscle.

Serratus Posticus Superior. In rare cases the whole muscle has been absent. Absence of one or more digitations is not infrequent. It is occasionally of larger size than normal. The writer once saw it arise from the four lower dorsal spines, and two upper lumbar, and go to be inserted into the five lower ribs.

Splenius. The extent of origin of the splenius varies. It not infrequently reaches as high as the middle of the ligamentum nuchæ; it may even be attached to the occipital protuberance (as in the bear). In one subject, on both sides, the writer saw the splenii attached to the whole length of the ligamentum nuchæ, the occipital protuberance, the superior curved line of the occipital bone, and the mastoid process. The two muscles presented the appearance of an inverted triangle.

The splenius colli may have a slip of attachment to the third cervical transverse process. The writer has seen it send slips to the second and third cervical, and in one case to the cervicalis ascendens. The splenius capitis may be quite distinct from the splenius colli, or these two portions may be fused together. The colli portion has been reported absent.

Rhombo-atloid (Macalister). Splenius accessorius, adjutor splenii (Walther). This muscle has already been described with the rhomboid. It is a muscular slip going from the transverse process of the atlas to the serratus magnus, rhomboid or serratus posticus superior, and is looked on by Wood as indicating the first degree of differentiation in man toward the formation of the occipito-scapular muscle of the lower animals.

Ligamentum Nuchæ Replaced by Muscle. The writer, in one case, saw the upper part of this ligament replaced by strong muscular fibres, which were attached to the external occipital protuberance, the whole length of the occipital crest, and the posterior tubercle of the atlas and axis. The external border of this muscle consisted of a thick, round tendon, continuous below with the ligamentum nuchæ, which was normal from the spine of the third cervical vertebra.

Sacro-lumbalis. The inferior and superior accessory origins of the sacro-lumbalis are infrequently absent. The *cervicalis ascendens* may arise as low as the tenth rib, and be inserted as high as the third cervical.

Spinalis Cervicis. This is described by Henle as a normal muscle. It is very inconstant, and arises from the spines of the fifth, sixth, and seventh cervical and upper two dorsal vertebræ, and is inserted into the spine of the axis, and sometimes the spines of the third and fourth cervical vertebræ.

Extensor Coccygis (sacro-coccygeus posticus). This is the name given to some slender muscular fibres occasionally seen going from the lower end of the sacrum or the posterior inferior iliac spine to the coccyx. It is the homologue of the great caudal extensor of the lower animals.

Longissimus Dorsi. May vary somewhat as to the number and extent of its attachments. The writer once saw it receive accessory fibres from the spines of the third, fourth, fifth, and sixth dorsal vertebræ.

Spinalis Dorsi. The number of tendons of insertion may be reduced to three; one spine may receive two tendons.

Complexus. The biventer cervicis may be completely fused with this muscle. It may be fused with the trachelo-mastoid or longissimus dorsi. The number of vertebræ to which it is attached may vary from two to seven. A supernumerary fascia sometimes arises from the transverse process of the second dorsal vertebra, and is inserted into the occipital bone beneath the normal muscle. The biventer frequently receives accessory slips from some of the lower cervical or upper dorsal vertebral spines, or from the ligamentum nuchæ. Slips have been seen going to join it from the seventh cervical transverse process.

Multifidus Spinæ. The origin from the seventh cervical vertebra may fail. Muscular slips may run from the

necks of the first and second ribs to the fifth and sixth cervical vertebræ, as well as between other ribs and vertebræ.

Interspinales. Longer interspinous bundles are sometimes found passing over one or two vertebræ. In the neck the bundles are broader.

The short *Rotatory* muscles of the neck may be occasionally doubled.

External Intercostals. The last ones are sometimes wanting. Not infrequently they extend as far as the sternum between the costal cartilages. The lower intercostals occasionally are continuous with the external abdominal oblique.

Internal Intercostals. These frequently extend to the vertebral column. The last two are sometimes absent, or so small that it requires a very careful dissection to discover them.

Supra-costalis (Wood); *Rectus Thoracis* (Turner). This is a muscle which lies on the upper ribs in the antero-lateral part of the thorax, and generally extends from the first to the fourth rib.

It has been looked upon, (1) as the homologue of the thoracic extension of the rectus abdominis to the first rib, as is seen so often in mammalia, *e.g.*, cat, otter, beaver; (2) as a reproduction in man of the sterno-costal muscles of the lower animals, *e.g.*, dog, badger, etc.; (3) as belonging essentially to the scalene system of muscles, and corresponding to the condition seen in many animals. In the bear the scalene muscles extend back as far as the seventh or eighth ribs. The last view is probably the correct one.

Triangularis Sterni. This muscle varies much as to its extent and points of attachment. Absence of one or both muscles has been noticed. Theile reports a case where it extended to the clavicle. It is sometimes continuous with the transversalis abdominis, of which it is supposed to be a remnant or appendage.

Diaphragm. The sternal portion of the muscle is not infrequently wanting (Quain). Carruthers (*Lancet*, 1879) reports a case of absence of the left half of the diaphragm in a child which lived ten days. In this case there was hernia of the small, and part of the large, intestine into the thorax. Absence of portions of the diaphragm are occasionally seen, and in these cases there is nearly always hernia of some of the contents of the abdomen into the thorax. At a post-mortem held at the Montreal General Hospital in 1885, on a man aged forty, a portion of the left half of the diaphragm was absent, and through the opening the greater portion of the stomach protruded into the thorax.

A fleshy fasciculus has been seen passing from the border of the œsophageal opening to the œsophagus. Knox has described a *musculus hepatico-diaphragmaticus* arising from the left side of the central tendon and passing over the œsophagus to the right, dividing into two slips, one of which went to the under surface of the liver and, becoming tendinous, joined the obliterated ductus venosus and umbilical vein; the other crossed the right crus and was lost in the peritoneum.

Henle and Bourgery describe a muscular slip going from the costal cartilage of the seventh rib partly to the costal cartilage of the ninth, and partly across the middle line of the diaphragm to the opposite border of the sternal portion.

External Abdominal Oblique (obliquus externus abdominis). According to Macalister, the number of attachments to the ribs varies from six to nine, and one or more slips may be doubled, generally those arising from the eighth and ninth ribs. It is not uncommon to see absence of the highest and lowest digitations. The two lowest may be rudimentary, and an additional fasciculus may come from the lumbar aponeurosis. This muscle may be connected with the serratus magnus, as well as with the pectoralis major, by continuous fibres. The musculus sternalis, when present, may be intimately associated with the external oblique.

A fasciculus has been described going from the ninth rib to the skin over that region (Flesch). This is no doubt a remnant of the dorso-abdominal skin muscle of mammals. Poland ("Guy's Hospital Reports," 1841) reports a case where the external abdominal oblique became tendinous at a horizontal line on a level with the umbilicus. It was inserted as usual into the ilium and pubis, but had no connection with the linea alba or linea semilunaris; the internal edge of the muscle being external to the semilunar line, and leaving exposed the internal oblique. In this case the external oblique received a special fleshy fasciculus from the eighth rib, near its cartilage.

Internal Abdominal Oblique (obliquus internus abdominis). This muscle, like the preceding, is subject to variations in the extent of its attachments. Its upper or lower attachments may be reduced; it may have an additional slip of insertion into the ninth costal cartilage. A tendinous inscription in the upper part of this muscle has been described as not uncommon; it generally proceeds from the tenth or eleventh rib. Henle describes once finding in the anterior portion of this inscription a short, thin cartilage.

Accessory Abdominal Oblique (M. lateralis abdominis). This is a muscle situated between the two oblique muscles, which arises from the ninth, tenth, or eleventh rib, and passes down to be inserted into the crest of the ilium. The writer once saw this muscle on both sides of the same subject; on the right it arose from the tip of the twelfth, and on the left from the lower border of the eleventh, rib; this latter muscle was not inserted into the iliac crest directly, but blended with the aponeurosis of the external oblique behind and above the anterior superior spine of the ilium. Both muscles became broader as they reached their iliac attachment.

In some cases this muscle is attached to Poupart's ligament or to the sheath of the rectus.

Transversalis Abdominis. The extent of its attachments may vary. Cases are reported where it was attached to the whole length of Poupart's ligament. The spermatic cord may sometimes pierce its lower border, especially in those cases where the attachment to Poupart's ligament is more extensive than usual. Fusion of the muscle with the internal oblique has been observed, and total absence has been noticed by Macalister. A tendinous intersection has also been seen.

Rectus Abdominis. In some cases this muscle has been seen extending as high as the third, and even the second, rib. It is not uncommon to see a supernumerary slip going to the fourth rib. In most animals the rectus abdominis extends higher than it does in man; in many it reaches as far as the first rib, *e.g.*, in the bear, otter, beaver, cat, porcupine, etc. The writer once saw a slip go from the upper part of the rectus to the middle of the lower border of the pectoralis major. The number of tendinous intersections may vary; as many as six have been noticed in the negro.

Pyramidalis. This muscle varies much as to size. It is very frequently absent, and is occasionally double. When absent the lower part of the rectus is increased in size. It is a muscle which is of no use in man, and is a mere rudiment of the larger muscle which exists in marsupials. It is absent in many of the lower animals, *e.g.*, solipeds, ruminants, and many of the carnivora, as the dog, cat, bear, etc.

Quadratus Lumborum. Is sometimes attached to the eleventh rib, and to the bodies and transverse processes of the tenth and eleventh dorsal vertebræ. Lange ("Annals of Surgery," vol. ii., p. 289) figures a quadratus muscle sending a slip to the fascia covering the pleura between the twelfth dorsal and first lumbar rib.

Muscles of the Perinæum and Pelvis.—Sphincter Ani. The writer once saw the superficial fibres of this muscle continued up past the tendinous point of the perinæum, as a flat muscular slip 6 mm. broad and 5 ctm. long. This slip blended above in the middle line with the dartos of the scrotum (see Fig. 2378). Occasionally fibres of the transversus perinæi are inserted into this muscle.

Coccygeus. Is sometimes inserted wholly into the side of the sacrum (Quain).

Sacro-coccygeus Anticus (curvator coccygis). This is the name given to a few fleshy and tendinous fibres passing from the lower part of the anterior portion of the sa-

crum and coccyx. It is well developed in animals with tails.

Transversus Perinæi. This muscle is a very variable one. It is occasionally absent, or so small as to be with difficulty dissected out. It is sometimes inserted either partly or wholly into the accelerator urinæ (bulbo-cavernosus) muscle or sphincter ani. This muscle is not infrequently fan-shaped, covering the triangular space formed by the three perinæal muscles. In these cases the ischio-cavernosus forms one edge of the fan. The fibres are inserted into the accelerator urinæ, central tendinous point, and sphincter ani. The muscle is occasionally double, the extra slip joining the accelerator urinæ or levator ani. Henle describes a muscular slip springing from the fascia at the lower border of the gluteus maximus, and inserted

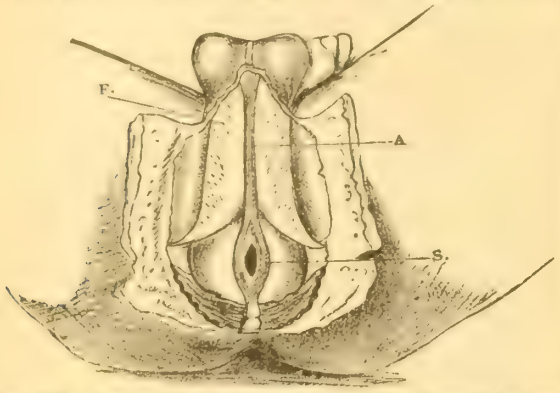

FIG. 2378.—*A*, sphincter ani continued upward in the middle line and blending with the dartos of the scrotum; *F*, perinæal fascia; *S*, sphincter ani. (Shepherd.)

into the lower surface of the triangular ligament. In one case of absence of this muscle, the writer found the deep transverse muscle of large size.

Ischio-cavernosus (erector penis). Houston has described a variety of this muscle under the name *compressor venæ dorsalis penis*. It is a slip arising in front of the ischio-cavernosus and crus penis, which passes upward and forward, and is inserted with its fellow into an aponeurosis above the dorsal vein. The writer once saw this extremely well developed. In the dog and some other animals it is quite a strong muscle.

Bulbo-cavernosus (accelerator urinæ). This muscle is occasionally joined by the transversus perinæi. Kobelt describes the fibres which cover the most prominent part of the bulb, and which are separated from the others by a more or less distinct interspace, as the *compressor hemisphericum bulbi*.

Francis J. Shepherd.

MUSCLES, DISEASES, WOUNDS, AND INJURIES OF. Protected by skin, fasciæ, and layers of fat, as well as by their own inherent resistance, itself enormous, the voluntary muscles are not easily injured, exposed though they are to violence and accident. Nor are they frequently the seat of disease, taking into account their high organization.

CONTUSIONS.—Muscles may be contused. The resulting temporary loss of power and severe pain on motion may lead to suspicion of more serious injury—as fracture of neighboring bones, rupture of tendons, or of the muscle itself. In mild cases complete recovery is the rule, while, if the injury is severe, the bruising of fibres and extravasation of blood may be followed, not only by permanent loss of power, but by atrophy with attendant degeneration.

In case recovery is not prompt, the galvanic current should be employed before degenerative change has proceeded too far.

SUBCUTANEOUS RUPTURE.—Slight lacerations involving a few muscle-fibrils are very common, taking place in most cases of strain. They are often accompanied by extravasation of blood. Temporary loss of power, with pain and stiffness, lasting often for many months, and recurring at intervals for a long time after, commonly follow. Complete muscular rupture is, on the contrary, a rare injury. It may depend upon either direct or indirect external violence, or upon contraction of the muscle itself. With the muscular fibre in a healthy condition, rupture from voluntary movement is probably impossible, but involuntary violent and spasmodic contraction of a single muscle may occasionally result in laceration.

In this way the muscles of the back, the *rectus femoris*, and the *psoas*, have been torn across by the violent contractions of tetanus; while the abdominal muscles have been ruptured by blows and falls against blunt objects; and the thigh extensors by the overstrain of sudden movements in running or jumping, or as the result of falls from a height upon the feet.

The power of resistance in a living and healthy muscle is very great, and separation of the muscle from its point of attachment, separation of the muscle from its tendon, or rupture of the tendon itself, is a much more frequent result of violence than is a complete subcutaneous rupture of the muscular tissue. The ruptures and lacerations, from even slight voluntary movements in the course of acute fevers, and particularly in the later stages of typhoid, are rendered possible by such degenerative changes in the muscular fibres (granular, fatty, or hyaline degeneration) as render them extremely brittle. The *rectus abdominis* is particularly liable to be thus torn; the thigh adductors, the *gastrocnemii* and *solei*, and the flexors of the forearm are less frequently affected.

The retraction of the divided ends of a completely ruptured muscle leaves, if the muscle be superficial, a deep indentation, soon, however, filled with effused blood. There is sudden, sharp pain at the time, unless, indeed, the rupture be one of those dependent on degenerative changes, when there are often no symptoms, the accident being unsuspected, and detected only post mortem. Treatment must consist in sufficient relaxation of the parts to permit approximation of the fragments, and in even compression by suitable bandaging, to control the muscular contractions.

Fixation by immovable dressings of plaster-of-Paris, or by the elastic bandages of Martin, will often best fulfil the indications. Absorption of the effused blood may be promoted by warm applications, and later, some stimulating liniment may be used. If union takes place, it is at first due to connective-tissue intermediate material, which soon condenses so much that a strong tendinous cicatrix results. In some cases there is probably direct reproduction of muscular tissue. More or less permanent weakness, and, if the rupture be of the abdominal muscles, some hernia of the abdominal contents may be expected. Where apposition cannot be maintained, as in rupture of deep-lying muscles, the widely separated fragments often become united to neighboring structures, and the use of the muscle is abolished. Muscular abscesses are not infrequently formed as the result of neglected rupture.

COMPOUND INJURIES.—These may be of various degrees, from simple cuts to complete pulpification of the tissues. On the amount of muscular laceration depends largely the prognosis, in cases of extensive injury. This is well recognized in compound fractures. From the greater amount of retraction that takes place when the supports of the muscle, as well as the muscle itself, are divided, there is usually much difficulty in bringing parts into apposition, and a large cavity is, in cases of rupture, left to fill with granulations. Almost complete abolition of function follows, and often deformity, from contraction of the granulation material.

Large masses of muscle sometimes protrude from a wound, on account of muscular rupture at some distance. These, unless much disorganized, should not be cut away, but cleaned and carefully returned; the skin opening being, if necessary, enlarged. With rest and proper support a useful limb has been obtained, even after rupture and protrusion of most important muscles. To maintain parts in apposition sutures have, in suitable cases, been advised. If used, they should include the whole body of the muscle.

If a muscle has been subjected to severe crushing

force, large portions may slough out, leaving more or less ragged "ulcers" to fill with granulations.

Ulceration of muscle is sometimes seen in severe phagedenic ulcers of the subcutaneous tissue.

Hæmorrhage into Muscles.—Intermuscular hæmorrhage as a result of violence is common. It also occurs in pyæmic conditions—in typhus and typhoid fever, in scurvy, small-pox, yellow fever, cholera, glanders, etc., and is then directly dependent upon degenerative changes in the tissues about the vessels which lessen their capacity for resistance, or is secondary to muscular rupture due to the same cause. Absorption of the clot is the rule when hæmorrhage follows violence; though, if this process is delayed, a thick membranous or cartilaginous sac sometimes remains, and causes permanent weakness of the affected muscles.

In glanders and allied disorders, foul abscesses are often formed by the breaking down of hæmorrhagic material. If, after an injury (subcutaneous muscular rupture, for instance), the effused blood be not absorbed within a reasonable time, the aspirator may be used, and, this failing, it may be even advisable to cut down, with suitable antiseptic precautions, and turn out the clot, removing at the same time, if possible, the sac-wall, which has generally been formed. In cases of long standing this is the only treatment available.

Embolic Infarctions have been occasionally found in muscles.

Hernia of Muscles.—An abnormal opening in the aponeurosis, which may be the result of external violence—as from a knife or bullet, or of laceration during sudden and violent muscular contraction—while usually healing spontaneously, is occasionally followed by protrusion of the muscle. Marked impairment of functional activity results in all cases, whether the hernia has been developed suddenly, or more slowly. In acute cases pain on motion is often severe. A distinct fulness and protrusion with the muscle contracted, disappearing when it is again relaxed, serves as a diagnostic sign; this symptom is absent in abscess, blood extravasation, muscle rupture, or visceral hernia, with which, in certain cases, the accident might be confounded. In acute cases rest and pressure will usually effect a cure. In case union of the divided aponeurosis does not take place, and the degree of discomfort warrants it, the edges of the laceration may be freshened and united by sutures.

A supporting bandage to limit the degree of protrusion is usually, however, sufficient.

Dislocations.—Dislocation of the whole or part of a muscle, while not as commonly recognized an accident as displacement of the tendons, is yet by no means a rare occurrence. A slender muscle, among those of greater volume, may, by irregular contractions, easily be jerked out of the muscular mass. The accident seems particularly liable to happen to the muscles about the spine, and to those of the forearm. The posterior portion of the sterno-mastoid has, in a case falling under the writer's notice, been frequently displaced. In so-called "lawn-tennis arm" the tendon, and sometimes the body, of the *pronator radii teres* is thrown out of position by motions incident to the game of tennis.

Dislocation follows sudden or unusual movements. Severe local pain, increased by certain movements, or of intensity sufficient to prevent these, results. Sudden and absolute relief follows reduction—generally accomplished by rubbing with the fingers the affected muscle, previously put in a state of complete relaxation. In case of failure, Callender, who has written briefly on this subject, directs continuance of pressure and forced action of the muscle, which, though painful, is usually effective. Redislocation is common, and a pad and retentive bandage are often for a time advisable.

Contractures.—Inflammatory changes often terminate in muscular shortening and deformity. Early treatment by friction, massage, stimulating applications, or electricity, may restore the functional activity; but if the condition persists for a long time, irreparable damage ensues, contraction becomes contracture, and myotomy or tenotomy can alone effect a cure. When the inflammation is one of the manifestations of syphilis, antisyphilitic treatment is, of course, called for, and is indeed often important as an aid to diagnosis. Reflex contractions without disease of muscle are seen in the neighborhood of diseased joints, as in morbus coxæ and spinal caries. After a time, however, inflammatory and degenerative changes take place in the disused muscles, and the contraction becomes permanent. Apparent contraction is often really due to paralysis of the opposed muscles (certain cases of *talipes*).

Myalgia (muscular pain).—One of the commonest of sensations is that of pain in one or more muscles, of varying duration and intensity. The so-called growing pains of childhood, the pain and sense of fatigue after violent exercise, as, for example, that felt in the legs after a long walk, or in the costal muscles after immoderate laughter, are physiological examples of this muscular pain or myalgia. In persons in feeble health, pain may occur after every slight exertion, and there may also persist a more or less painful state of many of the muscles, particularly in the trunk and back; the pain being, as a rule, more marked near the tendinous insertions. This constitutes true myalgia, and is often accompanied by cramps at intervals. The pain in the side, so common in women, though often a neuralgia of the intercostal nerves, is sometimes referred to the costal insertions of the external obliques, and is an instance of this. Inflammation and congestion of underlying organs, for which myalgia in the trunk is often mistaken, can be excluded, from the absence of fever and the relief obtained by rest and support. A weak and rapid pulse, unaffected by the pain, is almost constantly present as a symptom of the originally enfeebled state of these patients. Pain in the muscles may be also due to muscular strain or rupture; to neighboring local disease; to more or less central pressure upon the afferent nerve; or to the poisons of lead, syphilis, gonorrhœa, rheumatism (?), and the specific fevers, small-pox, typhoid fever, etc. In relapsing fever excruciating muscular pain is one of the most prominent symptoms, while the severe rheumatoid pain in scurvy is muscular in situation. Though the pain is often purely neuralgic in character, we must allow an inflammatory element in many cases, since so-called gonorrhœal and rheumatic attacks are sometimes followed by atrophy and contractions. The treatment of the true myalgia is by tonics, with rest and support to the affected muscles. In the other cases the cause must be sought for and removed.

Acute Inflammation of Muscle; Acute Myositis; Abscess in Muscle.—Acute inflammation in muscle is rarely spontaneous. As a result of violence, strain, or rupture of muscular fibres, or due to extension of inflammation from neighboring parts, it is not infrequent. The spontaneous form is most frequently met with in the psoas muscle, where it generally results in abscess. Bryant, indeed, regards this spontaneous inflammation (psoitis) as a more common cause of psoas abscess than spinal caries itself. Spontaneous inflammation also occurs in the rectus abdominis, diaphragm, and the muscles of the tongue, abscess being in these situations not so usual. In traumatic myositis suppuration is not common. There is more or less pain; the functional activity of the part is interfered with; a tender swelling of moderate extent, due to serous effusion, or sometimes in part to extravasated blood, is present, with associated heat and dryness of the skin. Recovery generally follows proper attention to the other effects of the injury, without special treatment. Neglect may lead to the formation of abscess. In pyæmic conditions, secondary inflammations and purulent deposits are common in all muscles. In glanders and farcy these muscular abscesses are particularly prominent and, to some extent, characteristic of the disease. This "acute suppurative myositis" has been met with in erysipelas and in diphtheria, and, in some few cases, single muscles or groups of muscles have been entirely destroyed by necrotic processes of septic origin. The affected muscles are at first hyperæmic. The interstitial tissue contains many small cells. Pus-cells accumulate. The muscular fibres undergo degenerative change (fatty or hyaline de-

generation), or disintegrate into foul-smelling masses swarming with bacteria. Abscesses are formed containing putrid pus and necrotic muscle-tissue, and causing, by mechanical pressure, still further atrophy and degeneration of the muscular fibre. In milder cases, with moderate pus accumulation, recovery may take place by interstitial-tissue proliferation, but with more or less muscular atrophy due to compression. The sooner a muscular abscess can be opened the better the prognosis. Simple abscesses readily heal after incision, leaving little or no trouble behind. In the abscesses and inflammations of septic origin, numerous free openings offer the only chance of preventing a fatal issue.

Acute Parenchymatous Inflammation.—Delafield gives this name to a few cases, reported by German physicians, where certain muscle groups were swollen, softened, and filled with yellowish patches. The muscle-fibres were in a state of granular, fatty, or hyaline degeneration. Capillary hæmorrhages were, in some cases, present. No explanation is offered, but the nervous system seemed not to be at fault.

Chronic Inflammation; Chronic Myositis.—Characterized by extensive interstitial cell proliferation, rendering the affected portion hard and painful, this form of inflammation may attack the muscle as a whole, or infiltration may be limited to one or several portions. Spontaneous muscular inflammation is generally chronic. In infants the *sterno-mastoid* is the muscle usually attacked. Appearing at, or soon after, birth, the disease affects the whole muscle. Suppuration rarely, if ever, occurs, and the affection yields readily, as a rule, to tonics and soothing applications. Fibrous organization of the exuded cell-products, with shortening of the muscle and resulting deformity may, however, occur. Orthopædic appliances, emollients, massage, etc., will then be useless, and myotomy or tenotomy can alone relieve the condition.

This so-called "congenital torticollis" has been considered due to fœtal inflammation, to injuries received during delivery, or to intra-uterine traumatism, twisting, etc.; but although generally found in puny children, it has not been attributed to syphilitic taint.

In the adult the disease is generally of syphilitic origin. It may, however, occur in muscles disused from any cause, in those which are atrophied, or as a result of repeated violences or the irritation of a foreign body. The inflammation may be diffuse, with general hardness, moderate swelling, tenderness, and pain; or, more rarely, a number of hard, tender, circumscribed swellings are scattered throughout the affected muscles, notably those of the tongue, thigh, arm extensors, temporals, and masseters. Abscesses rarely form, but after a time the cellular exudation organizes into contracting fibrous material, which, by pressure, produces atrophy, or even complete destruction, of the muscular fibres, and in cases of diffuse inflammation, often permanent deformity from muscular contraction. Where circumscribed inflammation is due to the formation of true syphilitic gummata, these are, if neglected through mistaken diagnosis, apt to break down, forming deep abscesses, and later ragged ulcers; otherwise, as the result of limited chronic myositis, there may be left a permanent fibrous tumor, which may subsequently become cartilaginous, or even bony. Syphilitic ulcerations in muscle bear so great a resemblance to ulcerating malignant tumors that it is often necessary to wait for the result of specific treatment before making an absolute diagnosis. This is notably the case in ulcerations of the tongue. In the muscles of so-called scrofulous subjects, cold abscesses are sometimes found. They are rarely large, and from their hardness and the absence of attendant inflammation, may be mistaken for solid tumors.

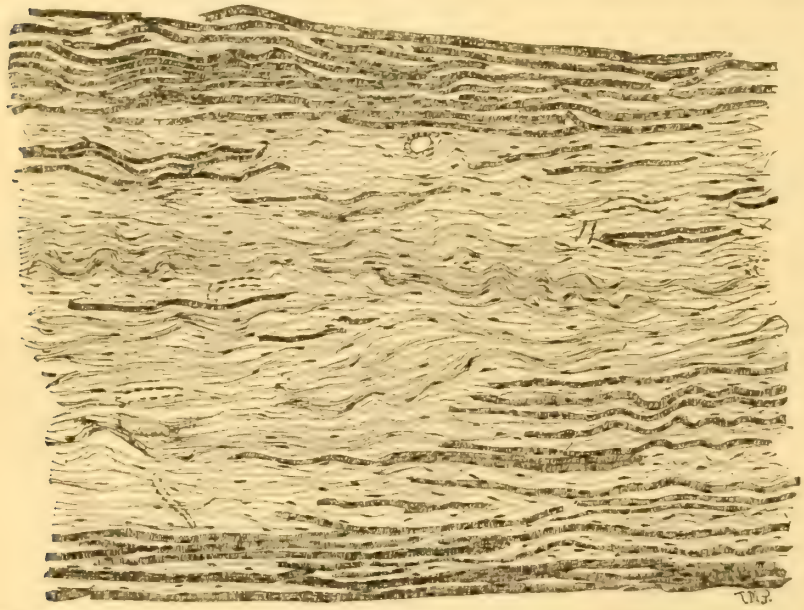

Fig. 2379.—Chronic Myositis. (× 350 and reduced.) (From Delafield and Prudden's "Handbook of Path. Anat. and Histology.") The atrophied remnants of muscle-fibrils are scattered through the dense cicatricial tissue.

Rheumatic Inflammation (so-called Muscular Rheumatism).—Generally a true myositis, terminating spontaneously in resolution in a short time; the morbid changes are, as a rule, limited to congestion and serous exudation. Assumed to be caused by draughts of air on the overheated or perspiring body surface, it is doubtless often due to some twist or sprain of the muscle involved. Repeated attacks in the same muscle, or group of muscles, are common. The muscles most often affected are those of the back (lumbago), of the chest (pleurodynia), and of the neck (so-called rheumatic torticollis). From organization of the exuded inflammatory products contraction and deformity may, though rarely, result. Suppuration probably never occurs. Rest, opium, local heat, and stimulating applications, with, in severe cases, electricity, are the most reliable remedies.

Gonorrhœal Inflammation.—A rare myositis occurring as a complication of gonorrhœa, always associated with an arthritis, and affecting by preference the muscles of the arm, forearm, and thigh. It differs from simple myositis in nothing but the exciting cause.

Ossification of Muscle.—True bone may be formed as the result of chronic inflammation in either one or several muscles. Circumscribed muscular ossification is not rarely found in the neighborhood of exuberant callus. The so-called exercise bones, due to slight violences often repeated through long periods of time, though generally found in tendons, may be situated in the muscles themselves. The bony plates sometimes found in the thigh adductors of horsemen, and the so-called "drilling bone" formed in the arm of soldiers are examples. The preceding connective-tissue inflammation may, however, be of specific origin. These plates of bone, once formed, are generally easy of detection, and though, as a rule, causing little discomfort, may require removal on account of interference with the muscular functions.

Myositis Ossificans.—In this rare disease a general muscular inflammation slowly progressive in character, terminates in atrophy of the muscular elements, and conversion of the inflammatory products into true bone. It

is thought to be generally independent of any nerve lesion. Beginning in childhood, it affects primarily the muscles of the trunk, and particularly those of the back, and extends to the extremities, sparing the muscular structures of the heart, larynx, œsophagus, and diaphragm. Death results from exhaustion, or from implication of the external muscles of respiration; but, as a rule, patients survive for many years, and often die only from some intercurrent malady.

The skeleton which is pictured in the accompanying figure is in the museum of the Steeven's Hospital, Dublin, Ireland. The disease began at the age of five. At the autopsy, twenty-five years later, there were found ossified, on the left side, the anterior edge of the masseter, the internal pterygoid, pectoralis major, part of the longissimus dorsi, pronator quadratus, rectus femoris, the lower part of the vasti, and the flexor brevis digitorum; on the right side, the trapezius, latissimus dorsi, erector spinæ, teres major, subscapularis, pectoralis minor, pronator quadratus, gluteus medius and minimus, pectineus, vastus externus, and flexor brevis digitorum. There had been no pain during the entire course of the disease. Death occurred from double pneumonia.

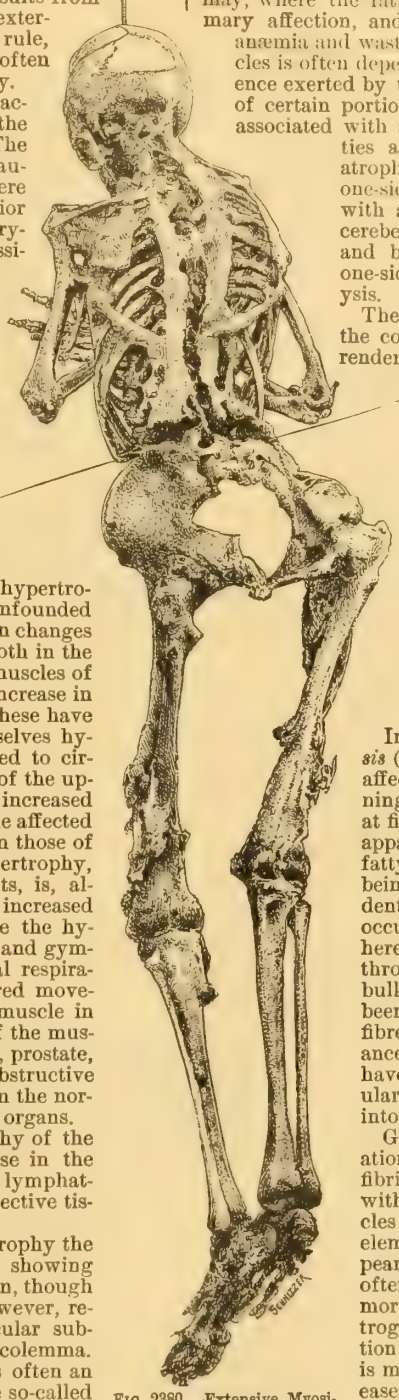

Fig. 2380.—Extensive Myositis Ossificans. (From a photograph of the specimen in the Steeven's Hospital, of Dublin.)

Tubercular Inflammation.—Tubercle has occasionally developed in the inter-muscular tissue.

Muscular Hypertrophy.—A true hypertrophy of muscular substance, not to be confounded with an increase of volume dependent on changes in the intermuscular tissue, is found both in the voluntary muscles and in the smooth muscles of various organs. Generally due to an increase in the number of the muscular elements, these have been found, in some few cases, themselves hypertrophied; the change being confined to circumscribed groups of muscles, usually of the upper extremity. Sometimes capable of increased work, for a time, though soon tiring, the affected muscles are often actually weaker than those of normal dimensions. The muscular hypertrophy, with simple multiplication of elements, is, almost without exception, the result of increased activity. Familiar instances of this are the hypertrophied muscles of the blacksmith and gymnast; the enlargement of the external respiratory muscles in consequence of labored movements; the hypertrophy of the heart-muscle in obstructions of the circulation; and of the muscles in the intestine, stomach, bladder, prostate, etc., as a result of inflammation, or of obstructive stenoses which have imposed more than the normal amount of work upon the affected organs.

So-called macroglossa, or hypertrophy of the tongue, is rarely due to actual increase in the muscle-fibres, but to hypertrophy of the lymphatics, blood-vessels, and investing connective tissue.

Muscular Atrophy.—In simple atrophy the ultimate fibres retain their structure, showing both longitudinal and transverse striation, though with less distinctness. They are, however, reduced in size. Sometimes the muscular substance in places disappears from the sarcolemma. Associated with this condition there is often an increased interstitial deposit of fat, the so-called fatty infiltration, sometimes of sufficient amount to cause an apparent hypertrophy of the affected muscle. Atrophy, dependent upon general defective nutrition, occurs in the course of all wasting diseases, in typhoid and other fevers, in phthisis and the various cachexiæ, and in old age. It occurs, locally, as a result of lessened function and diminished irritation in paralyzed muscles, and those insufficiently used, as in the muscles connected with a diseased joint, or the fragments left in a stump after amputation. It may be the result of direct pressure by a tumor or foreign body; or fatty infiltration, generally a secondary process, may, where the fat is in excess in the blood, be the primary affection, and mechanically cause, by pressure, anæmia and wasting. Atrophy of the voluntary muscles is often dependent upon interruption of the influence exerted by the vaso-motor nerves; and absence of certain portions of the central nervous system is associated with such rare though striking deformities as crossed lateral atrophy and hemiatrophia facialis, in the former of which a one-sided atrophy of the cerebrum coexists with atrophy of the opposite half of the cerebellum, spinal cord, nerves, muscles, and bones; while in the latter we have a one-sided atrophy of the face without paralysis.

The prominence of muscular atrophy in the course of the three following diseases renders it desirable to mention them in this connection, though they are treated of at length elsewhere.

In the first of these, or *progressive muscular atrophy*, there is a combination of chronic inflammatory hypertrophy of the interfibrillar connective tissue, with atrophy of the compressed muscle-fibres, either simple or with added fatty or hyaline degeneration.

In *infantile paralysis* (the essential paralysis of childhood) atrophy follows the paralysis, after a considerable interval. Degeneration occurs still later, if a cure be not effected.

In *pseudo-hypertrophic muscular paralysis* (*atrophia musculorum lipomatosa*), the affected muscles—generally, in the beginning, those of the lower extremities—are at first enlarged, hard, and firm. This apparent hypertrophy is dependent upon fatty infiltration, the muscular elements being in a state of atrophy. Later, evident wasting of the voluntary muscles occurs, and the microscope shows, only here and there, a muscular fibre running through the fatty tissue, into which the bulk of the true muscle-substance has been converted. Of these remaining fibres some retain their normal appearance, others are atrophied, and still others have lost their striation and become granular, or have been partially converted into fat.

Granular Degeneration.—The striation of the ultimate fibres is lost. The fibrillæ are swollen, opaque, and filled with fine granules. The affected muscles are friable and easily rupture. The elements may recover their normal appearance and function, or the disease, often the precursor of the fatty metamorphosis, may be followed by this retrograde change, and complete destruction may result. Granular degeneration is met with in fevers and severe acute diseases, in the first stages of phosphorus poisoning, and, associated with atrophy, in paralyzed muscles, and in such diseases as progressive muscular atrophy and infantile paralysis.

Fatty Degeneration.—Minute granules of fat appear, generally in longitudinal rows, beginning in the neighborhood of the nuclei, and increase in number and

size until they occupy the whole space within the sarcolemma, and complete wasting of the muscle-fibre results. This process is to be distinguished from that of fatty infiltration, where fat is deposited in the intermuscular tissue, the muscular elements remaining unaffected. Macroscopically the affected portions are yellow and friable. Fatty degeneration attacks most frequently the heart.

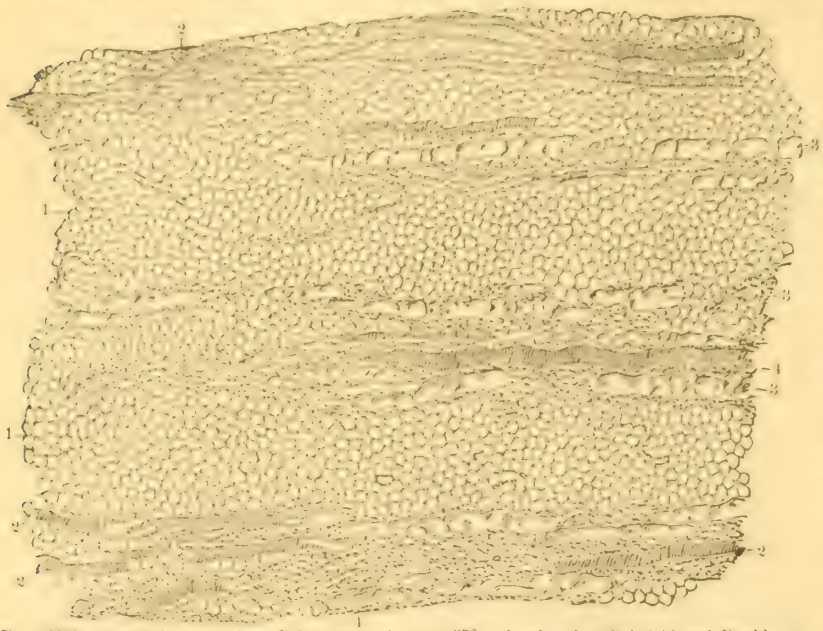

Fig. 2381.—Pseudo-hypertrophy of Gastrocnemius. × 350 and reduced. (Delafield and Prudden.)
1, Interstitial fatty infiltration; 2, atrophied muscle-fibrils; 3, muscle-fibrils that have undergone waxy (hyaline) metamorphosis; 4, granular detritus from granular degeneration of other fibrils.

It is met with, in the voluntary muscles, in scurvy; in severe acute, and wasting chronic, diseases; in poisoning by phosphorus; associated with other changes in progressive atrophy and pseudo-hypertrophy; and in muscles atrophied or paralyzed from any cause.

Hyaline Degeneration; Waxy Degeneration; Vitreous Degeneration.—By some supposed to be largely a post mortem change, this form of degeneration affects by preference the muscles of the chest and abdomen, the diaphragm, and the thigh adductors. The affected muscles are soft and easily tear. It occurs chiefly in the course of severe fevers, notably in typhoid, but also in typhus, acute miliary tuberculosis, small-pox, scarlet fever, etc. It has been found locally in tetanus, trichinosis, extensive freezing, and in the neighborhood of malignant tumors.

The disease appears in patches in the affected muscles, and attacks but a proportion of the fibres in its chosen seat, healthy and diseased muscle-fibrils being seen side by side. The affected portions present a homogeneous, waxy appearance, the striation disappears, the ultimate fibrils broaden and are converted by degrees into hyaline material, prone to break up into irregular masses, though sometimes retaining the original shape of the fibre. Interfibrillar hyperplasia and granular degeneration are often also present, and the affected fibres may crumble and disappear, leaving the sarcolemma as an empty sac.

Pigmentary Degeneration.—Characterized by the presence of pigment granules in the muscle-fibrils, and usually connected with the various atrophies and degenerations dependent upon nutritive disturbances; this pathological condition is generally due to decomposition of the hæmoglobin of the blood. In many cases, however, the source of the pigment is uncertain.

Simple atrophy, without new-formation of pigment, may cause a decidedly deeper hue in muscles which are normally somewhat colored, as those of the heart.

Calcification.—Lime salts are occasionally deposited in both smooth and striated muscle-fibre. This is one of the changes incident to old age.

Muscular Anæsthesia.—Diminution of common sensation in muscles is usually met with in connection with loss of voluntary power, but occasionally by itself. Diminution of the special muscular sensibility, or of that sense by which we know the force a contracting muscle is exerting—true muscular anæsthesia—is commonly associated with disease of the central nervous system, and particularly with affections of the spinal cord. There is no knowledge of the amount of resistance to be overcome by a contracting muscle, and the patient becomes dependent, for his information of the movements and position of his limbs, on the cutaneous impressions and the ocular sense. Muscular co-ordination is accordingly interfered with. The incoordinate movements in walking, and the inability to stand with the eyes closed, so characteristic of locomotor ataxia, are dependent upon this diminution of muscular sense. Besides the loss of sensibility in ataxia and hysteria, there is sometimes sudden anæsthesia, due, probably, to obscure localized changes in the cord. Rest and counter-irritation usually result in cure.

Muscular Hyperæsthesia.—Eulenberg claims that there is an increase of muscular sensibility in chorea and in writer's cramp. But little is known on the subject.

Muscular Tremors.—Besides the spasmodic contractions, tonic and clonic, which occur as the result of nerve irritation, and which will be discussed elsewhere, delicate clonic contractions, affecting single fibres, are met with. These fibrillary spasms and twitches are seen in the old and feeble, in the first stages of progressive atrophy, and, according to Fournier, in syphilis unconnected with nerve lesion, and of simply functional character.

Tumors.—Primary tumor of the muscle-substance of any kind is rare. Secondary infiltration and invasion from neighboring tissues are not infrequent. The fibrous, fibro-cartilaginous, and bony tumors following inflammation have been already considered. Of all the

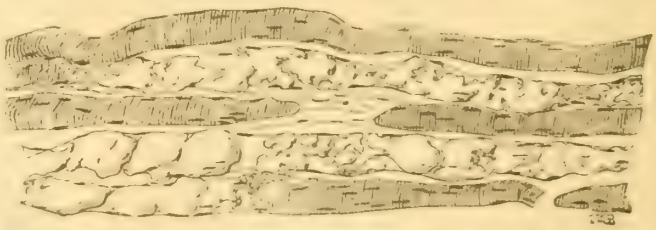

Fig. 2382.—Hyaline (waxy) Degeneration of Abdominal Muscles in Typhoid Fever. (Delafield and Prudden.)

new-formations, fibrous tumors are, perhaps, the most common. The most important, and practically the only remaining, varieties are the various forms of vascular tumor and the malignant growths.

The *malignant tumors*—sarcoma and carcinoma—may undoubtedly originate in muscle, though generally present as the result of infiltration. Teevan, in sixty-two cases of primary muscle tumor, reports twenty-one as malignant. All of these were either sarcomatous or encephaloid cancer. Scirrhus seems never to originate in muscle. Malignant growths may begin either in the interfibrillar tissue or in the fibril itself. They may be present in the

latter as distinct tumors, as infiltrations, or by substitution, the sarcous elements being displaced by cancer-cells, and little or no observable change taking place in the muscle. Complete and speedy removal is the only treatment; the proper accomplishment of which often necessitates enucleation of the whole muscle, or even amputation of a limb.

Vascular Tumors.—Erectile tumors in muscle are generally invasions by growths originating in the skin and subcutaneous connective tissue, but new-growths in the interior of the voluntary muscles have been reported by Demarquay, Liston, Cruveilhier, and others. According to Mr. Campbell de Morgan, they are found: first, as tumors having the appearance of a varicose condition of the veins, unconnected with the surrounding muscular tissue, and yet not isolated by a connective-tissue envelope; second, encroaching on the muscular tissue, with no definite boundary between the two; third, as distinct tumors surrounded by a connective-tissue capsule. The muscular substance is atrophied, and has often undergone fatty change, while in one remarkable case, reported by Cruveilhier, the biceps and muscles of the forearm were almost entirely replaced by erectile tissue, only here and there a muscular fibre remaining.

Fibro-cystic, lipomatous, and myxomatous tumors are occasionally met with, as primary growths of the interfibrillar tissue.

Parasites.—The most important of these is the *trichina spiralis*, which, in its encysted state, has been found in all, or almost all, the muscles of the body. The entrance of the worms into the muscles causes an acute myositis, evidenced by muscular cramps, pain, hardness, and tenderness on pressure. The functions of the affected muscles are impaired, there is destruction of the sarcous elements, and also cellular infiltration of the intermuscular tissue. When full-grown, the parasites become encapsulated and a chronic inflammation takes place around them. Later, calcareous matter is usually deposited in the capsule walls.

Cysticerci and Echinococci are also met with in muscular tissue, the former of small size and causing no symptoms, being rarely detected during life; while the latter, usually causing disturbance by their size alone, may set up an acute inflammation with resulting abscess and spontaneous evacuation, or may become encapsulated as the result of chronic irritative myositis.

The *Pelodera Setigera*, "a free nematoid," was, according to Bastian, once found two months after death in the muscles of a boy dying from some obscure febrile disease (Quain's "Dictionary of Med.," art. Pelodera).

Samuel B. Woodward.

MUSCULAR TISSUE. Histology of Muscular Tissue.—Muscular tissue (Lat., *Tela muscularis;* Ital., *Tessuto muscolare;* Fr., *Tissu musculaire;* Ger., *Muskelgewebe*) is the tissue in the animal body, the physiological characteristic of which is its power of contracting in one direction, thus giving rise to definite movements. It is composed of structural elements, the length of which is usually much greater than the breadth. Muscular tissue in some form is present in all the groups of animals, except the *Protozoa*.*

Anatomically or morphologically, muscular tissue is of two kinds: (A) *Striated or striped muscular tissue*, that in which the structural elements or fibres are marked by distinct transverse, and usually much less distinct, longitudinal striations. The structural elements are multinucleated (Figs. 2384 to 2395). (B) *Smooth or unstriated muscular tissue*, that in which the structural elements are apparently homogeneous, or marked by fine longitudinal striations only. The elements are mostly uninucleated (Figs. 2404 to 2407).

Striated Muscular Tissue.—This, in man and many of the lower animals, is the so-called flesh or lean meat. It is usually collected into more or less distinct masses, termed *muscles;* and in every case, whether the muscle is in distinct masses or not, it is composed of structural or histological elements, which, when viewed lengthwise under a microscope, are characterized by an appearance of being composed of alternating dark and light segments (Figs. 2384 to 2402); this gives the elements their transversely striated appearance. Physiologically, striated muscle is characterized by the rapidity and energy of its contraction.

Distribution.—Striated muscular tissue is present in all vertebrates and in some members, at least, of all the great groups of invertebrates except the *Protozoa*. Structurally and physiologically, striated muscular tissue in vertebrates is of two kinds: (A) The skeletal, or the so-called muscle of animal life, which is mostly voluntary; (B) the cardiac, or the muscular tissue of the heart, and

Fig. 2383.—Transection of the Occipito-scapularis Muscle of the Cat, to show the Components of an Ordinary Striated Muscle. The whole muscle and the fascicles were outlined with the camera lucida at a magnification of about twenty diameters. The muscular fibres, the artery, vein, and nerve were not drawn to scale. In the lower left-hand side of the figure many fascicles were omitted in order to give place to a single fascicle magnified three hundred and eighty diameters, and showing the relative size and shape of the individual fibres, the endomysium, and the blood-supply. (Drawn by Mrs. Gage.) *a*, Artery; *c*, capillaries, most of them in transection (the lower one to which the line extends is shown lengthwise, and represents a capillary extending across instead of parallel with the muscular fibres (compare Fig. 2395); *e*, endomysium, the connective tissue between the individual fibres; *m-c*, muscle-corpuscles (the lines extend to one in the interior, and one at the exterior of the same fibre); *p-e*, perimysium externum, connective tissue surrounding the entire muscle and giving off (*p-i*) the perimysium internum, which combines the fibres into bundles or fascicles of various sizes; *n*, nerve; *v*, vein.

the other pulsating organs of the blood vascular system. This is wholly involuntary, and belongs to the tissues of organic life.

Skeletal or Voluntary Muscular Tissue (Muscles of animal life).—In man and the mammals generally, this tissue forms from forty to forty-five per cent. of the entire body weight. Its specific gravity is about 1.058. It is usually collected into distinct muscles, the ends of which are in most cases attached to some firm part (bone or cartilage) by means of fibrous connective tissue.

Distribution: In man and the mammals generally, this tissue forms the muscles of the trunk and extremities, those moving the globe of the eye and all those of the ear, those moving the lips, and those moving the skin (*platysma myoides* in man, the cutaneous muscles over nearly the entire body in many mammals). It is also present in the tongue, pharynx, larynx, the true sphincter of the urethra, and the ectal sphincter of the anus; in mammals possessing them, it is found in connection with Cowper's and the anal glands. In the œsophagus of man, the horse, and some other animals, striated muscle is usually present only in the pharyngeal half; in ruminants, the dog, cat, rabbit, house-mouse, rat, and

* Among the *Protozoa*, the striated ectoplasm of some infusoria, and the contractile stalk of *Vorticella* are perhaps physiologically muscular tissue, but they can hardly be so considered anatomically, since these organisms are supposed to be unicellular.

many other animals, it extends to, or nearly to, the stomach; and in the rat it is even continued upon the stomach from the cardiac end of the œsophagus. In many of the lower vertebrates, besides the muscles of the trunk and limbs, striated muscular tissue is found in situations where it is not present in man. *In birds*, in the iris and choroid; *in snakes* around the poison-glands; *in teleostean fishes*, in the wall of the stomach of *Cobitis fossilis* and *Synganthus acus*, and in the intestine of *Tinca chrysitis*; in *ganoid fishes*, in *amia* it forms a double layer over the surface of the lung-like air-bladder, and is present in the trabeculæ-like cords within it, in *lepidosteus*, it is very abundant in the trabeculæ within the air-bladder, in *polypterus* there is present an enclosing sheet of muscle for the air-bladder as in *amia*.

Constituents of Striated Muscular Tissue.—These are: (A) the essential and characteristic, elongated and transversely striated, muscular fibres (Figs. 2384 to 2395); (B) blood- and lymph-vessels (Figs. 2383 and 2395); (C) nerves (Fig. 2383); (D) a considerable quantity of adipose and connective tissue (Figs. 2383 to 2386). The connective tissue of a muscle has received special names according to its position in the muscle: (*a*) *perimysium externum* (Fig. 2383, *p–e*). This is the connective tissue which forms a kind of envelope or sheath for the entire muscle; (*b*) *perimysium internum* (Fig. 2383, *p–i*). This is the connective tissue which extends into the muscle from the perimysium externum. It combines the fibres into bundles (*fasciculi*, *fascicles*, or *lacerti*) of various sizes, and separates the fascicles from one another; (*c*) *endomysium*. This is the minute network of connective tissue extending from the perimysium internum into the fascicles, and separating the individual fibres from one another. Finally, connective tissue, commonly in dense masses or tendons, serves to connect the muscles to other parts, usually bones or cartilages, which are moved when the muscle contracts.

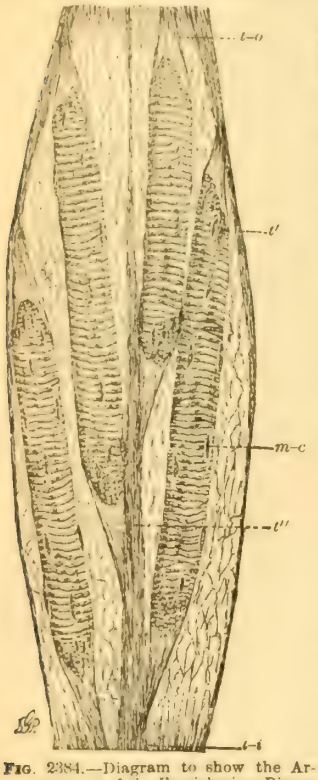

FIG. 2384.—Diagram to show the Arrangement of the Fascicles in a Bipenniform Muscle (*Biceps Brachii* of the Cat). Each Fibre Represents a Fascicle. (Drawn by Mrs. Gage.) *m–c*, Muscle-corpuscle; *t–i*, tendon of insertion; *t–o*, tendon of origin; *t′*, tendinous expansion over the surface of the muscle (it is thickest near the tendon of origin); *t″*, extension of tendon through the middle of the muscle. It thickens toward the tendon of insertion.

Fascicles (*fasciculi* or *lacerti*) *and their Relations in a Muscle.*—In some muscles, as the sartorius, the muscular fascicles extend from end to end of the muscle. In such a case, if the muscle has a broad tendon of origin and insertion, the fascicles are usually nearly parallel and of nearly the same length. Where, however, one or both ends are fusiform, as in the biceps brachii and gracilis of man, the central are considerably the longer. In penniform and bipenniform muscles the fascicles are placed obliquely to the long axis of the muscle, and extend for a comparatively small part of its entire length. In case of the bipenniform muscles—biceps brachii of the cat (Fig. 2384), quadriceps femoris of man—the tendon of origin and the tendon of insertion extend along the entire length of the muscle, on the surface, and also in the central part. This arrangement of the tendon in the penniform and bipenniform muscles renders it obviously impossible to expose the muscular substance in dissection so that it shall show to the best advantage. In most muscles the component fascicles are approximately parallel with one another, although not necessarily with the long axis of the muscle. In bipenniform muscles the fascicles are parallel with one another on the same side, but at an angle with those of the opposite side (Fig. 2384); they are likewise oblique to one another in the fan-shaped muscles like the pectorals and the latissimus.

Fibres and their Arrangement in a Fascicle.—It was long supposed that the individual fibres forming a fascicle were coextensive with it, and therefore, except with the penniform and bipenniform muscles, with the muscle itself. It was shown, however, by Rollett,[1] Herzig, and Biesiadecki,[2] that the fibres may end within a fascicle, being attached to a tendon at but one extremity, or at neither. It is now believed that a fibre rarely exceeds forty millimetres in length, while a muscular fascicle may be, in some cases, ten or twenty times that length, or even longer. If the fascicle is not over forty millimetres long, the fibres usually extend parallel with one another from end to end of the fascicle; and where the fascicle is parallel with the long axis of the muscle, and the muscle itself does not exceed forty millimetres, the individual fibres likewise extend its entire length (Fig. 2385), as in the occipito-frontalis and many other muscles of the cat, the stapedius, and some other muscles in man. Where, however, the fascicles considerably exceed forty millimetres in length, the fibres which originate in the tendon of origin or insertion by blunt ends, terminate by fusiform ends at different levels within the fascicle (Fig. 2388, A). Where the fascicles greatly exceed forty millimetres in length, part of the fibres originate and terminate as just described, while those which fill the intervening space are tapering and slender at both ends (Fig. 2388, B). In all cases where the fibres become tapering and end within a fascicle, each tapering end is applied closely to a fibre of full size (see Fig. 2388, and below, under Termination of the Fibres).

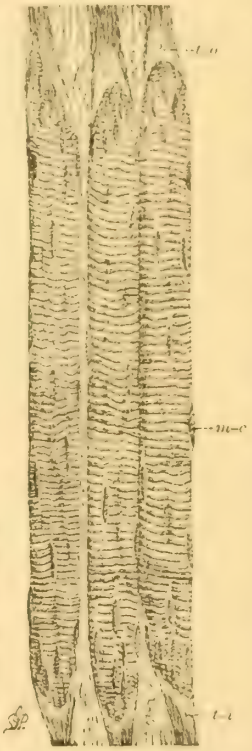

FIG. 2385.—Diagram of a Striated Muscle in which the Fascicles are composed of but One Length of Fibres, which are of nearly Equal Length. It also represents a muscle less than forty millimetres in length, in which the fibres are parallel and extend from end to end of the muscle. (Drawn by Mrs. Gage.) *m–c*, Muscle-corpuscle; *t–i*, tendon of insertion; *t–o*, tendon of origin.

In small animals, like the common mouse and bat, where none of the muscles attains a length of forty millimetres, the question as to the relations of the fibres of a fascicle has been but slightly investigated. Kölliker found that in the limb-muscles of the bat the fibres extend the entire length of the fascicle. In the house-mouse the writer found some of the fibres ending within the fascicles as described above, but most of the fibres extended the entire length of the fascicle. A similar condition was shown by Herzig and Biesiadecki to exist in the muscles of the frog, some of the fibres extending the entire length of the fascicle, while others terminated within it. As stated above, the fibres in a fascicle are approximately parallel, and the fascicles, composed of but one length of fibres (Fig. 2385), show the same number of fibres in transection at any level, and each fibre is of nearly the same diameter throughout its entire length, except at the extreme

ends (Fig. 2385). In a fascicle composed of two or more lengths of fibres, the number of fibres varies in transections made at different levels, and the same fibre is not of uniform diameter throughout its entire length (Fig. 2388). Independently, however, of the tapering ends of the fibres in fascicles composed of two or more lengths of fibres, the several fibres of a fascicle in all forms of muscles vary greatly in diameter, and there is also a great difference in the number of fibres in the different fascicles (Fig. 2383). The coarseness or fineness in texture of a muscle to the naked eye, depends mostly on the relative abundance of the perimysium and the *number, not the size*, of the fibres in the component fascicles (Fig. 2383).

Termination of Striated Muscular Fibres.—(A) *Termination in Tendon.*—The most common mode is in a dense, usually rounded or flattened mass of connective tissue called a tendon. This is always less bulky than the muscle, and consists of a continuation of the connective tissue of the muscle, and of the special minute tendinous prolongations of the individual fibres which reach the tendon (Figs. 2384 to 2386). All muscular fibres ending in

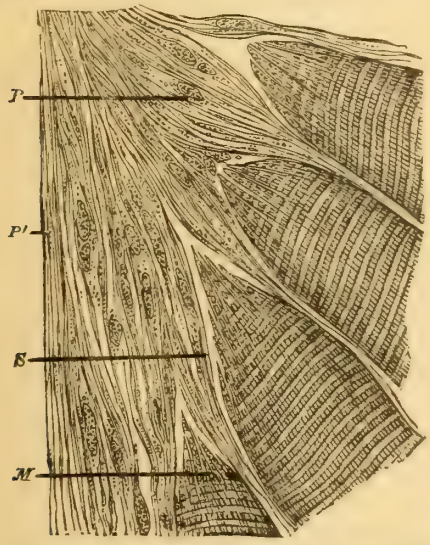

Fig. 2386.—To show the Attachment of Muscle to Periosteum (apparent direct attachment to bone), also an Oblique Muscular Attachment. From the scapula of a cat. Magnified 500 diameters. (Heitzmann.) *M*, tendinous ends of a striated muscular fibre (four are shown); *P*, perimysium; this intermingles with the periosteum, and, with the short tendinous prolongations of the individual fibres, serves as a tendon; *P'*, periosteum; the perimysium and tendinous prolongations of the muscular fibres intermingle with the fibres of the periosteum and become lost in it; *S*, sarcolemma; apparently continued as part of the tendinous prolongation of the fibre.

tendon, or apparently directly upon some hard part—bone or cartilage—terminate as just described, without regard to the angle of attachment; there is simply a difference in the length of the tendinous prolongations of the fibres (Fig. 2386).

When a muscular fibre reaches a tendon, the sarcous substance (see below) ends bluntly (Figs. 2384 to 2388). In some cases the end is divided into several short finger-like processes. Whatever the form of the terminal part of the sarcous substance, the fibre appears to be directly continued by a conical bundle of tendinous tissue, which soon loses itself in the general mass of the tendon (Figs. 2384 to 2388). This appearance is clearly seen in the dead muscular fibres of all the animals examined; it is shown with the greatest distinctness in the muscular fibres of the caudal appendages of the living and uninjured larva of the neuropterous insect of the genus *Sialis*. It was long held by most histologists that this appearance indicated that at its termination in a tendon the sarcous substance merges directly into tendinous substance, and with the sarcolemma (see below), forms the tendinous insertion of the fibre. At the present day, however, many histologists believe that the sarcolemma of a muscular fibre is continued around the end of the fibre, and that the tendon is simply cemented to it (Fig. 2387). The sarcolemma has never been separated from the tendon, so that, if this view is correct, the connection between the sarcolemma and tendon is more intimate than that between the sarcolemma and sarcous substance. This interpretation is a natural, and almost necessary, outgrowth of the cell doctrine of Schwann[3] and his followers, which teaches, above all things, the independence of the individual structural elements. And these writers consider the sarcolemma a kind of cell-wall; it must, therefore, necessarily entirely enclose the fibre, and the tendon be cemented to it at the end of the fibre. To the constantly increasing number of biologists who believe, not in the independence, but in the interconnection of the structural elements of the body, there seems no inherent improbability in the view that muscle may merge into tendon, and the sarcolemma become continuous with, and form part of, the tendon. The appearances obtainable by treating dead muscular fibres with various reagents, and by the study of living fibres, give, in the present state of knowledge, justification to either interpretation.

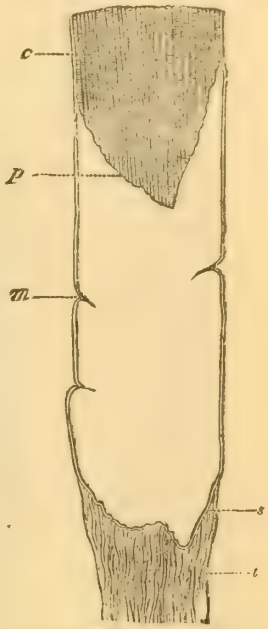

Fig. 2387.—Muscular Fibre from the Gastrocnemius of the Frog, to show the Termination of a Muscular Fibre in Tendon. Magnified 140 diameters. (Ranvier.) *c*, Muscle-columns; *m*, a fold in the empty sarcolemma; *p*, retracted conical termination of the sarcous substance; *s*, sarcolemma reflected over the end of the fibre and adhering to the tendon; *t*, tendon.

(B) *Termination of Fibres within a Muscle.*—The statements of histologists concerning the termination of fibres within a muscle and the relations of the terminal ends are so various, or directly conflicting, that some of the more positive statements will be given before stating what seems, according to the writer's observations, to be the condition. Frey, 1880: "While it was formerly supposed that every transversely striated fibre continued throughout the entire length of its muscle, more recently numerous exceptions to this have been observed; that is, muscular fibres which terminate in a point, or some other form, at a greater or lesser distance from the tendinous extremity. Such primitive fasciculi have their connection with the tendon, to a certain extent, in the interstitial connective tissue." Klein, 1883: "The individual fibres have only . . . . a relatively limited length, so that, following an anatomical fascicle from one point of its insertion to the other, we find some muscle-fibres terminating, others originating. This takes place in the following way: The contents of a fibre suddenly terminate, while the sarcolemma, as a fine thread, becomes interwoven with the fine connective tissue between the muscular fibres." Landois, 1885: "Within a short muscle, *e.g.*, stapedius, tensor tympani (of man), or the short muscles of a frog, the fibres are as long as the muscle itself. Within longer muscles, however, the individual fibres are pointed, and are united obliquely by cement substance with a similar bevelled or pointed end of another fibre lying in the same direction." Schaefer, 1882: "In a long fasciculus a fibre does not reach from one tendinous attachment to the other, but ends with a rounded extremity, invested with its sarcolemma, and cohering with neighboring fibres."

According to the writer's observations on many different muscles of cats at all ages, and less extended observations upon human muscles and on those of the

house-mouse, the fibres which terminate within a muscle always do so with a very tapering end, the extremity becoming thread-like, and losing its striation. The muscle-corpuscles (see below) are also numerous near the

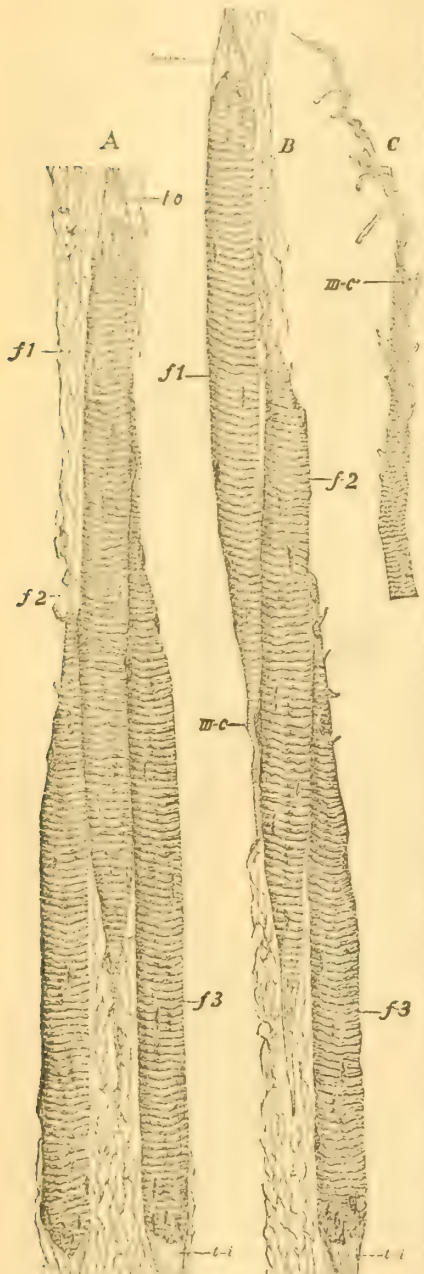

FIG. 2388.—Diagrams to show the Relation and Termination of Fibres. a. Fascicles composed of Two or more Lengths of Fibres. (Drawn by Mrs. Gage.) *A*, Fascicle composed of two lengths of fibres. The fibres terminate by rounded ends at the tendon of origin and insertion, and in the midst of the muscle by tapering ends which are applied to the other fibres, where they are of full size. *f* 1, Fibre arising at the tendon of origin and terminating in the midst of the muscle; *f* 2, and *f* 3, fibres of different lengths arising at the tendon of insertion and terminating in the midst of the muscle: *t-i*, tendon of insertion; *t-o*, tendon of origin. *B*, A fascicle composed of three lengths of fibres; only the ends reaching the tendons are rounded, the others are tapering and are applied to neighboring fibres, as in *A*. *f* 1, Fibre arising at the tendon of origin and terminating in the midst of the muscle; *f* 2, fibre with tapering ends, both of which terminate in the midst of the muscle; *f* 3, fibre terminating by a rounded end in the tendon of insertion, and by a tapering end in the midst of the muscle: *m-c*, muscle-corpuscle. This one projects beyond the surface of *f* 2, and the tapering end of *f* 1 curves over this corpuscle. A similar condition is shown in *f* 1, *A*; *t-i*, tendon of insertion: *t-o*, tendon of origin. *C*, The terminal part of a fibre ending within a muscle. Drawn with a camera lucida at a magnification of 425 diameters. The details of structure were determined with a $\frac{1}{18}$ homogeneous immersion objective, and added free hand. *m-c*, Muscle-corpuscle. The one to which the line extends, projects markedly, and is in the angle formed by a lateral branch. The lateral branches are numerous, and some of them show distinct transverse striations. Just beyond the corpuscle to which the line extends the transverse striation ceases on the fibre. At the end is an enlargement or corpuscle, with a thread-like continuation.

end, and in some cases the fibre seems to terminate as a branched corpuscle (Fig. 2388, *C*). Small lateral branches, some of them striated, were also present in many cases (Fig. 2388, *C*). Herzig and Biesiadecki describe long lateral branches, some of which even anastomose, in the terminating muscular fibres of the horse. Where the fibres were apparently undisturbed in their relations, the terminal part, for a considerable distance, was parallel and closely connected with a fibre of full size, the tapering end following accurately the outline of the fibre to which it was applied, curving outward over a muscle-corpuscle (Fig. 2388, *m-c*), or when the large fibre was corrugated, following the curves accurately. The fibres arising from the same tendon and terminating within a muscle, may be of various lengths; in such a case the longer ones may apply their tapering ends to fibres of full size coming from the opposite tendon (Fig. 2388, *A*), while the shorter ones may either apply themselves to fibres from the opposite tendon, or to the longer fibres from the same tendon. In the latter case the shorter fibre has always been observed to terminate before the longer one commenced to taper. When a fascicle is three or more fibres in length, the fibres may be of various lengths, as stated above, but the fibres not joined to the tendon of origin or insertion are tapering at both ends. All the fibres lap sufficiently to apply their tapering end to fibres having their full diameter (Fig. 2388, *B*). In all the numerous preparations observed by the writer, the muscular fibres terminating within a muscle were always very slender and tapering at their termination, and two tapering ends were never seen to lap and be cemented together; but the slender termination of one fibre was invariably applied to a fibre of full size, and terminated before the supporting fibre commenced to taper. The apparent termination of a fibre by a rounded end within a muscle is due, in many cases at least, to the tearing and retraction of the sarcous substance, and sometimes also of the sarcolemma. In the great majority of cases observed, where a fibre was in its natural relations to the other fibres, and seemed to end by a blunt or rounded extremity within the fascicle, the empty sarcolemma was traced to the other broken end. When the hollow sarcolemma appears of about the size of a muscular fibre (Figs. 2387, 2390), the true relations of the broken ends of the fibre are readily determined; but in many cases the stretched sarcolemma collapses and tapers to a point about midway between the severed ends of the sarcous substance, and often both the broken ends cannot be seen in the same field of the microscope.

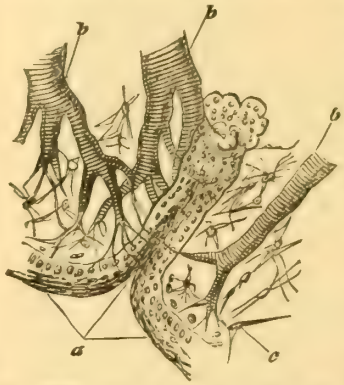

FIG. 2389.—Section of the Lip of the Rat through the *Musculus Levator Labii Superioris*, to show the Branching of the Fibres and their Termination in the Corium. (Busk and Huxley.) *a*, Epidermis and aperture of a sebaceous gland; *b*, muscular fibres branching and terminating in the corium after tapering and losing their transverse striations; *c*, connective-tissue corpuscle.

(C) *Termination of Muscular Fibres in the Skin.*—The attachments of the cutaneous muscles to hard parts, and the terminations of the fibres within a muscle, are as described above for the ordinary muscles. At their cutaneous termination the fibres (in the cat at least) taper somewhat gradually, lose their transverse striation, and, finally, become indistinguishable from the white fibres of the corium. In some animals, as the rat, the fibres at their cutaneous termination, in the lips at least, divide into several branches, which taper gradually or somewhat suddenly, lose their striation, and in some cases appear to terminate in connective-tissue corpuscles; in others they become indistinguishable from the white fibres of the corium (Fig. 2389).

(D) *Termination of Muscular Fibres in Mucosa.*—If one end of the muscle is attached to some hard part, or if the fibres terminate within the muscle, the attachment of the fibres to the tendon, and the termination within the mus-

cle are as described above for the ordinary skeletal muscles. The ends of the fibres terminating in the mucosal corium, taper, sometimes branch, always lose their striation, and are lost in the fibrous tissue of the mucosa.

(E) *Termination of Striated Muscular Fibres in Hollow Viscera, and in Connection with Unstriated Muscular Fibres.*—In the œsophagus, urethra, etc., where the fibres for the most part have no connection with a definite tendon of origin or insertion, they end by tapering extremities, the tapering part being joined to fibres of full size, as in the ordinary skeletal muscles (Fig. 2388). Where the striated fibres mingle with, and are gradually replaced by, unstriated fibres, as at the gastric or cardiac end of the œsophagus, the long tapering ends of the striated fibres are surrounded on all sides by the unstriated fibres, to which they seem to be cemented as the unstriated fibres are cemented to one another (Fig. 2404).

In all cases (skin, mucosa, hollow viscera, and in the interior of muscles where the fibres gradually taper to thread-like terminations), the sarcolemma, if present on the tapering ends, is so closely connected with the fibre that it is exceedingly difficult or impossible to demonstrate it; and near the end of the fibre the striation is so gradually lost that it is difficult or impossible to locate the exact termination of the sarcous substance and the beginning of the tendinous substance—if it may be so called. No one has ever been able to show a relation of the non-striated termination of the tapering fibres to the sarcolemma, anything like that shown in Fig. 2387; and according to Busk and Huxley, such tapering fibres with non-striated endings furnish conclusive proof that the sarcous substance merges directly into tendinous substance. According to Beale, fibrous degeneration of the sarcous substance points in the same direction.

Branching of Striated, Skeletal, Muscular Fibres.—In the invertebrates striated muscular fibres frequently branch and anastomose, especially in the walls of the alimentary canal. In vertebrates these fibres rarely divide, except when terminating in mucosa or skin. Kölliker described tree-like branchings in the mucosal ends of the muscular fibres of the frog's tongue; and Herzig and Biesiadecki have described and figured muscular fibres from the frog's tongue which possess tree-like branches at both ends. According to Klein, branching fibres have also been found in the tongue of the newt, bat, sheep, goat, cat, and man. Salter[4] could not demonstrate them in man. Branched terminations in the tongue of mammals are certainly greatly in the minority, and are much more difficult of demonstration than in the tongue of the frog. In the skin of the rat's lip branching fibres have been described by Busk and Huxley (Fig. 2389). Finally, the ordinary skeletal muscular fibres are sometimes dichotomously divided. This is especially evident in the tapering ends of fibres terminating within a muscle (Fig. 2388, *C*). Anastomosing branches even were described and figured in the muscular fibres of the horse. Short finger-like divisions at the tendinous ends of fibres are common.

Structure of a Striated Muscular Fibre (*Primitive Fasciculus or Fascicle*).—The striated muscular fibres are the structural or anatomical elements of the skeletal or voluntary muscular tissue. They are cylindrical or prismatic in form, and rarely exceed 40 mm. in length, most of them being considerably shorter. In diameter, the general average in man is from 30 μ to 65 μ, being somewhat larger in the male than in the female; in the cat 25 μ to 90 μ; in mammals below man 45 μ; in birds 31 μ; in reptiles and amphibia 56 μ; in fishes 100 μ; in insects 63 μ. The variations in size in the same animal are very great, *e.g.*, in man some of the fibres are 125 μ, while others are only 10 μ in diameter.*

Structurally, most of the fibres are composed of two very different parts—an enclosing membrane, sarcolemma, and the contractile or sarcous substance, which includes the muscle-corpuscles.

Sarcolemma (*Myolemma, Primitive Sheath*).—It was shown by Bowman[5] and Schwann,[3] independently, that most striated muscular fibres are covered by a thin, elastic, and transparent membrane, comparable if not identical with, a cell-membrane. It has not been demonstrated in the striated muscular fibres of amphioxus and petromyzon (Balfour), nor in many of the fibres of the tongue of man and other animals (Busk and Huxley[6]), nor in fibres of the eyelid and eyeball, nor in most of those of the myelo-hyoid of the green tree-frog (Beale[7]). According to some writers it is not present in developing fibres, except near the end of development. In its chemical and physical nature the sarcolemma is quite similar to elastic tissue, so that when the dead fibres are dissected with needles, either before or after special chemical treatment, the sarcous substance (see below) is more often torn than the sarcolemma, which remains intact and connects the severed ends of the sarcous substance (Fig. 2390). The sarcolemma, under favorable circumstances of light and preparation, does not appear homogeneous, but fibrillated and punctated, and in some cases there seems to be a connection between the sarcolemma and the endomysium. Occasionally, when the sarcous substance is torn and retracted, a thin layer remains adherent to the sarcolemma, around part or the whole of the circumference. In such a case the sarcolemma appears striated, but much less opaque than the whole fibre (Fig. 2390). When the entire sarcous substance retracts, the sarcolemma appears like a hollow transparent sac, and is often folded (Fig. 2387, 2390). If the fibres are considerably stretched in preparation, the sarcolemma joining the broken ends of the sarcous substance may become very slender, and appear like a tendinous termination. In most cases, however, the sarcolemma may be traced between the retracted ends of the sarcous substance, although both ends may not be visible in the same field of the microscope. Whether the sarcolemma simply encloses the sarcous substance as the finger of a glove covers the finger, or whether it has a structural connection with the sarcous substance, is not yet determined. According to the views of Krause, delicate partitions arise from the sarcolemma and pass entirely through the muscular fibres, dividing it into compartments. When the sarcolemma of insects is slightly raised from the surface of the fibre, it is wavy, and at the part of the wave nearest the sarcous substance a delicate process is seen to extend to the muscular substance. This appearance was pointed out and figured by Bowman, and may be seen with the greatest clearness in the muscular

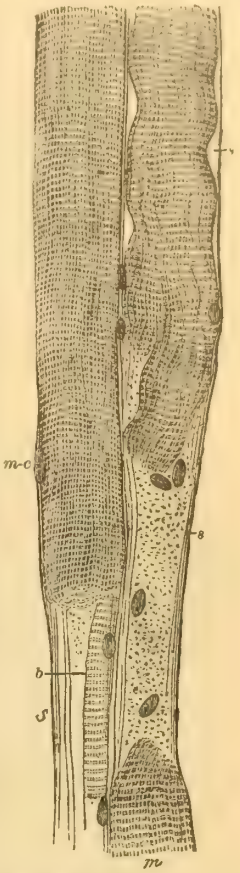

Fig. 2390.—Parts of two Muscular Fibres from the Adductor Magnus of a Dog, to show the Sarcolemma between the Broken and Retracted Ends of the Sarcous Substance. Magnified 270 diameters. (Ranvier.) *b*, A thin layer of sarcous substance adhering to the sarcolemma. This sometimes adheres all the way around and gives a striated appearance to the sarcolemma; *m*, sarcous or muscular substance; *m-c*, muscle-corpuscle. In the fibre at the right some muscle-corpuscles have been separated from the fibre and remain in the empty sarcolemma; *s*, sarcolemma; *s'*, opposite a space between the sarcous substance and the sarcolemma.

* It is not stated by the authors from whom the above figures were taken (Kölliker and Bowman), whether, in obtaining the diameter of the fibres, the cut ends, as seen in transections, were measured, or whether isolated fibres were measured, nor whether care was taken to avoid tapering ends of fibres terminating within a muscle. In the measurements given for the fibres of the cat by the writer, only isolated fibres were measured, and care was taken to measure them only where they were of full size.

fibres of the larva of *corydalis*. The common appearance in vertebrate muscle is that shown in Figs. 2387, 2390, where the sarcolemma seems to be simply an enclosing sac.

Sarcous Substance (*Muscular or Contractile Substance*).—This substance forming the essential or contractile part of a muscular fibre is, during the life of the fibre, of a semifluid consistence, and, both before and after death, appears to be composed of alternating dark and light disks. There is also, in many cases, an appearance of longitudinal striation (Figs. 2384 to 2392). While the gross appearance of a striated muscular fibre is so evident and characteristic, the finer structure has proved one of the most difficult problems in histology.*

The difficulty of the investigation is greatly increased because it is so hard to distinguish between appearances which may be purely optical and those which are due to structural differentiation. The case is well stated by Bowman (1840): "The improvements which have taken place in the construction of microscopes appear, indeed, to have only afforded grounds for new differences of opinion;" and by Leydig (1885): "The complexity of structure of muscular tissue, and the fineness of its component parts give rise to so many doubts, that one is often led to wish that it were possible to go beyond the present attainable enlargement and perfection of the microscopic image." The most varied animals are selected from which to obtain muscular tissue for this most difficult investigation; insects and crustacea are favorite objects, from the distinctness of the structural details in their muscular fibres. No matter what animal is chosen, it is too often assumed that the structure of all striated muscle is identical with that under consideration—an assumption which often requires the imagination to fill out details not visible when muscle, other than that taken as the standard, is examined. From his own study, the writer believes that all the appearances described by original observers may be demonstrated, if muscles from a sufficiently great number of animals are studied both before and after the application of a sufficiently large variety of chemical agents, and if a microscope having sufficient range of magnification and excellence of image is employed.

FIG. 2391.—Diagram to show the Disks and Fibrillæ into which a Striated Muscular Fibre may be separated. (Stowell.) A, Short piece of a muscular fibre broken transversely into Bowman's disks, and appearing something like a pile of coins; B, fibrillæ into which a muscular fibre may be divided longitudinally.

It was shown by Bowman,[5] whose paper in the "Philosophical Transactions," 1840, is the most prominent landmark for the histology of striated muscular tissue, that the fibres have a tendency to break up into fine fibrils (*primitive fibrillæ*), which extend parallel with the long axis of the muscle, and appear in structural details like the entire fibre (Figs. 2391, 2392), and that they may also break up into disks which are at right angles to the long axis of the fibre (Fig. 2391). In breaking into disks (*Bowman's disks*), the plane of cleavage is through the middle of the light disk (Figs. 2392, 2393); each disk of Bowman is therefore composed of an entire dark disk, with half a light disk at each end. These appearances were considered by Bowman to indicate, not the existence of fibrils and disks in the living muscle, but of minute rounded or angular particles (*Bowman's sarcous elements*), which form the true contractile part of the fibre; and that these are connected together on all sides by a more fluid and non-contractile substance—that connecting the sarcous elements end to end into fibrils—differing somewhat from that connecting them side by side into disks, as is shown from the fact that the reagents causing the muscle to divide into fibrils do not cause it to break readily into disks, and those causing the fibre to divide into disks do not cause it to break readily into fibrils. When, however, the cementing materials at both the sides and ends give way, the sarcous or ultimate elements of the fibre are, according to Bowman, isolated. Bowman's views were so simple, and so in accordance with observed facts, that they were almost universally accepted. There is, however, great difficulty in deciding what should be considered a primitive fibril composed of a single row of sarcous elements placed end to end, as it is possible to separate a fibre into fibrils so small that the structural characters are difficult of determination. The term *sarcous element*, to indicate the ultimate structural and contractile part of a muscular fibre, has been retained by most histologists, although the interpretation of what constitutes a sarcous element varies with almost every original investigator.

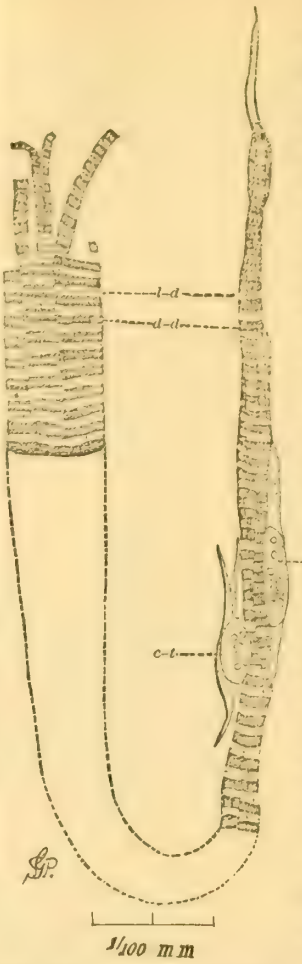

FIG. 2392.—The Terminal Part of a Muscular Fibre ending within a Muscle, to show the End of the Fibre, Isolated Fibrils, and the Various Disks which are sometimes seen in Mammalian Muscle. From the latissimus of a kitten five weeks old. The fibre is not striated beyond the swelling near the terminal end, and a striated branch is present on the right side just beyond the large muscle-corpuscle. At the larger end the disks are displaced so that part of a dark disk is opposite a light disk. The entire length of fibre here shown is 0.95 mm. The intermediate part, indicated by dotted lines, is greatly abbreviated. Drawn with a camera lucida at a magnification of 800 diameters. All the details of structure were determined with a $^1/_{18}$ homogeneous immersion objective. (Drawn by Mrs. Gage.) *c-t*, Connective tissue corpuscle partly covering the fibre; *d-d*, dark disk. This is very distinctly divided into two equal parts by a narrow light band (middle or Hensen's disk, compare Fig. 2393); *l-d*, light disk. This is divided into two equal parts by a narrow dark band (membrane of Krause, intermediate disk, compare Fig. 2393); *m-c*, muscle-corpuscle. The cell-body, nucleus, and nucleoli are all very distinct.

The following are a few of the more important modifications or enlargements of the views of Bowman upon the intimate structure of striated muscular tissue:

(A) *Action of Polarized Light.*—It was shown by Bruecke (1857) that the sarcous elements of striated muscular tissue are *anisotropic* (doubly refractive), and act like positive uniaxial crystals, while the intermediate substance is *isotropic* (singly refractive). As the sarcous elements retain their anisotropic character apparently unchanged during the shortening and broadening of contraction, Bruecke supposed that they were not simple but compound bodies, and he applied the term *disdiaclasts* to what he considered the elementary particles composing the sarcous elements, thus borrowing the terminology of Bertholin, who used this term to designate the hypothetical crystals of calc-spar. On the whole, it cannot be said, however, that polarized light has been of material aid in comprehending the structure and action of muscular tissue.

* In the epidermis of *lampreys*, and perhaps also in some other fishes, there are large clavate cells which resemble very strikingly short pieces of striated muscular fibres. Not only is the agreement very marked, both in ordinary and polarized light, but the resistance of these cells to the action of caustic potash is like that of muscular tissue (Max. Schultze, Arch. f. Anat. u. Phys., 1861, p. 281).

(B) *Muscle-compartments, Additional Disks.*— It was shown by Bowman that, in addition to the broad light, and broad dark disks, there sometimes appeared a narrow, dark line in the light disk and a narrow light band in the dark disk (Fig. 2392). The dark line in the light disk was also figured and described by Busk and Huxley, who considered it a disk composed of a row of minute sarcous elements. It has also been insisted on by Sharpey and Martyn, and later by Krause. Krause interpreted it as a continuous membrane (*Krause's membrane*), extending from the sarcolemma and dividing the muscular substance into compartments (*muscle-compartments*) which apparently correspond exactly in extent to the disks of Bowman (Figs. 2391 and 2392). The view that Krause's membrane is a real structure, which extends from the sarcolemma through the fibre, thus making a complete partition, is supported by the fact that when the sarcolemma of insect muscle is partly torn from the fibre, delicate processes are often seen to extend to or toward the sarcous substance from the sarcolemma opposite the middle of the light disk. This appearance has not been observed and figured for mammalian muscle. The view of a continuous membrane making a partition in the fibre at regular intervals is opposed by the fact that a worm has been seen to move along within the sarcous substance from end to end of the fibre. Furthermore, the sarcous substance of the fibre closed up behind the worm, and the fibre appeared as before and still showed unmistakable contractions. Also, that in living and contractile muscular fibres of insects, which are apparently uninjured, the disks sometimes become displaced for a short distance along a sharp line, so that a dark disk is opposite a light disk. The displacement of the disks is shown in Fig. 2392, but here it might have been due to the traction exerted in preparation, and hence does not bear upon this question as does the displacement of the disks in the living and uninjured fibre. Besides the disks just considered, German investigators have described others which are shown in the diagram (Fig. 2393).

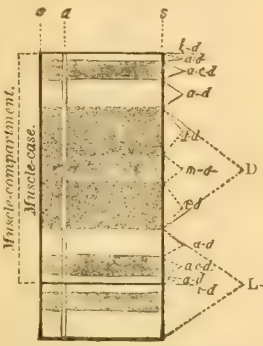

Fig. 2393.—Diagram to Show a Muscle-compartment, a Muscle-case, and the Disks into which a Muscle-compartment is divided, according to some Histologists. Modified from Engelmann. (Drawn by Mrs. Gage.) *Muscle-compartment:* This is one of the series of segments of which a striated muscular fibre is supposed to be composed. It includes one entire dark disk (D–D) and half a light disk at each end of the dark disk. It therefore corresponds in extent to a Bowman's disk. For those who accept the existence of Krause's membrane, it is the part of a muscular fibre between two such successive membranes. *Muscle-case:* This, according to Krause, comprehends a sarcous element (muscle-prism), with a limited amount of intermediate substance at the sides and ends. The whole case is enclosed by Krause's membrane at the ends, and a special membrane at the sides. In the figure, the muscle-case is the part of the muscle-compartment between *s* and *a*; D–D, *dark disk*, composed of two dark bands (*i–d*) separated by a lighter disk (*m–d*), *middle disk of Engelmann*, or Hensen's disk. L–D, *light disk:* This is composed of two symmetrical halves, each half forming the end of a muscle-compartment. Each half is composed of two light disks (*a–d*), and a granular disk (*ac–d*), the so-called *granular* or *accessory disk*, and the disk *i–d* (*intermediate disk*), the latter forming the boundary between two successive muscle-compartments. Krause's membrane is usually said to consist of the intermediate disk and the two adjacent accessory disks, with the light disks between them.

(C) *Muscle-cases.*—Besides the muscle-compartments, Krause considers that each sarcous element (muscle-prism) is entirely enclosed by a membrane (Krause's membrane) forming the end, and a special membrane forming the sides (Fig. 2393). At the ends and sides of the sarcous element, within its complete membrane, is a more fluid, non-contractile substance.

(D) *Cohnheim's Areas, Muscle-columns.* — Cohnheim in 1863, showed that in transections of frozen muscular fibres, there appeared dark polygonal areas (Cohnheim's areas), surrounded by narrow light lines. He supposed that the dark areas were the cut ends of sarcous elements, and the light intermediate substance was the lateral cementing material. It was found, however, that a Cohnheim's area might be far too large to represent a section of a single sarcous element, and the area often showed a punctated appearance; hence arose the conception that in a striated muscular fibre the fibrils are arranged in bundles (*muscle-columns*, Kölliker; *primitive muscular cylinders*, Leydig, Fig. 2387), something as an entire muscle is made up of fascicles (Fig. 2383), and that Cohnheim's areas represent sections of the bundles of fibrils (muscle-columns), so that a transection of an entire muscular fibre has the same general appearance as the transection of an entire muscle.
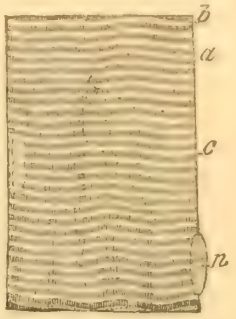
Fig. 2394.—Part of a Muscular Fibre from the Adductor Magnus of a Rabbit, to show the appearance of an extended mammalian muscular fibre. Magnified 700 diameters. (Ranvier.) *a*, Dark disk; *b*, Krause's membrane or intermediate disk; *c*, light disk; *n*, muscle-corpuscle seen in profile.

(E) *Schaefer's Dumb-bells.* — In 1873, Schaefer advanced the hypothesis that striated muscle is composed of a lighter intermediate substance, in which are imbedded rows of dark, dumb-bell shaped structures, each dumb-bell extending lengthwise of the fibre; and that the appearance of a light band is due to the strong refraction of light by the heads of the dumb-bells, which

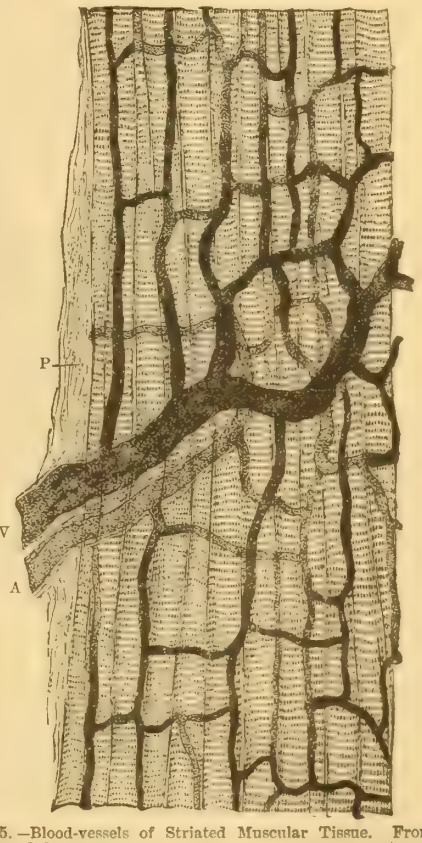

Fig. 2395.—Blood-vessels of Striated Muscular Tissue. From a cat. Magnified 300 diameters. (Heitzmann.) A, artery; P, perimysium; V, vein.

being at the same level, form a series of transverse rows, double the number of the light disks (Fig. 2414). Each dumb-bell head gives a little halo like that of a minute oil-globule, and the entire light disk is produced by the

sum of the halos of the heads of two successive rows of dumb-bells (Fig. 2414). The significance of the dumb-bells is not understood, as the lighter intermediate substance is the one supposed to be contractile.

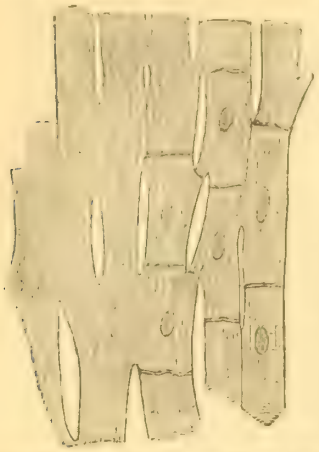

Fig. 2396. Cardiac Muscular Tissue from a Warm-blooded Animal, to show the Form, Branches, and Relations of the Cardiac Muscle-cells. On the right the limits of the separate cells with their nuclei are exhibited somewhat diagrammatically. Magnified. (Schweiger-Seidel.)

(F) *The Reticulated Arrangement of Contractile Substance.*—Heitzmann's (1873) introduced an entirely new idea as to the structure of striated muscular tissue—viz., that like simple protoplasm, the sarcous substance is made up of a reticulum of the true contractile matter, the meshes of this reticulum being filled by a more fluid intermediate substance. According to this view, the reticulum is so arranged that the nodal or crossing points (sarcous elements) are at regular intervals both transversely and longitudinally, the transverse row giving the appearance of a continuous dark disk, and the longitudinal row of a fibril. The light disk is traversed by the filaments of the reticulum, which pass between the nodal points. This hypothesis, with unimportant modifications, is now adopted by many histologists, and appears to be most in harmony with the latest views concerning histological structure.

Vascular Supply of Striated Muscle.—As in other tissues, the blood- and lymph-vessels of muscular tissue do not enter the structural elements or fibres, but are in the connective tissue surrounding them.

(A) *Blood-vessels.*—The blood-vessels of this tissue are very numerous, and are estimated to contain one-fourth of the blood in the entire body. As a rule, each muscle receives two or more arteries, and gives off a corresponding number of veins. The larger vessels run in the perimysium internum, and send small branches into the fascicles, where they break up into a characteristic, parallelogrammic network of fine capillaries, the longer part of the mesh extending parallel with the fibres. The capillaries are the smallest in the body, many of them being smaller than the blood-corpuscles of the animal to which they belong. In man the size varies from 3.5 μ to 6.5 μ (Kölliker, 1867) (Figs. 2383, 2395).

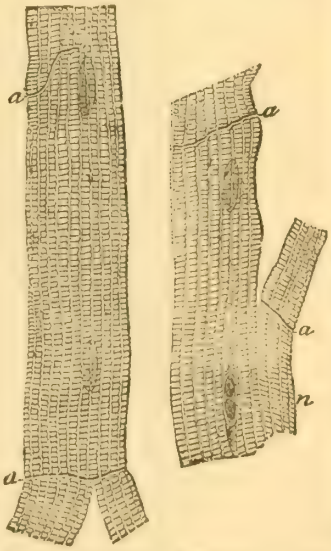

Fig. 2397.—Cardiac Muscle-cells of the Left Ventricle of a Dog, showing the Form, Branches, Nuclei, and Striæ of the Cells. The longitudinal, transversely striated bands in each cell represent muscle-columns. Magnified 600 diameters. (Ranvier.) *a*, Intercellular cement at the junction of the cells; *n*, nucleus. The one opposite the *n* shows a conical mass of unstriated protoplasm at each end (compare Fig. 2407, *a*).

It was shown by Ranvier that the transverse branches of the capillary network and the smallest veins often possess saccular dilatations which are supposed to serve as reservoirs of oxygenated blood to supply the muscles during a long-continued contraction, or to act as receptacles during a maximal contraction.

(B) *Lymphatic Vessels.*—The lymphatic vessels of striated muscular tissue are supposed to be numerous. They lie between the fibres in the perimysium and endomysium, and are said by Klein "to have the shape of continuous long clefts or channels."

Fig. 2398.—Cardiac Muscle-cells, showing their Form, Branches, Nuclei, and Striæ. From the heart of a young rabbit.* Magnified 425 diameters. (Schaefer.) *a*, Line of junction between the cells (intercellular cement); *b*, *c*, branches of the cells.

Nerves of Striated Muscle.—The nervous supply of striated muscle is exceedingly abundant, and consists of both motor and sensory fibres. The special terminations of the nerves in the tissue will be considered under Nerves (*q.v.*).

Cardiac Muscular Tissue.—This tissue is composed of branched, quadrangular or fusiform cells, with distinct transverse and less distinct longitudinal striation, and with, usually, but a single nucleus.

Distribution.—Cardiac muscular tissue is present in the heart of all vertebrates, and, so far as has been investigated, in all those parts of the blood-vascular system exhibiting rhythmical pulsations, as the *conus arteriosus* of amphibia and many fishes, and the great veins next the heart in mammals.†

Constituents of Cardiac Muscular Tissue.—These are: (*A*) The essential and characteristic contractile elements (cardiac muscle-cells); (*B*) connective tissue forming a kind of perimysium, penetrating between the muscular tissue and dividing it into layers and bands; (*C*) blood- and lymph-vessels and nerves.

Form and Size of the Cardiac Muscle-cells.—It was shown by Weismann[10] (1861) and confirmed by later observers, that the cardiac muscular tissue of all adult vertebrates is composed, not of elongated, multinucleated, branched, and anastomosing fibres, but of independent cells, mostly with but a single nucleus. The cardiac muscle-cells of adults differ greatly in form and arrangement, and naturally fall into two distinct groups: (*A*) That in which the cells are branched, quadrangular, and considerably longer than broad, averaging about 80 μ long and 20 μ wide. Those of the auricles are usually more slender than those of

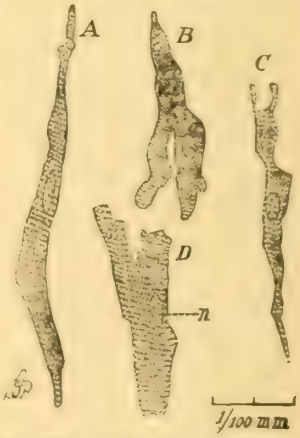

Fig. 2399.—Cardiac Muscle-cells from the Ventricle of a Minnow, to show the Forms of the Cells with their Branches, Nuclei, and Striæ in the *Teleostean Fishes*. *A*, Cell approximately fusiform in outline; *B*, branched-cell, which appears granular rather than regularly striated; *C*, cell with depression, in which a rounded end like the branch of *B* fits when the cells are in their normal relations (compare the middle cell and its relations in Fig. 2411); *D*, cell approximating in shape the cardiac muscle-cells of warm-blooded animals; *n*, nucleus. In cells *A*, *C*, the transverse striæ distinctly cross the nucleus.

* This figure appeared in Quain's Anatomy, eighth edition, p. 119, but the source was not given. On inquiry, Dr. Schaefer informed the writer that the cells are from the heart of a young rabbit.

† According to the investigations of Ranvier, the muscular tissue of the rhythmically pulsating *lymph hearts* of *amphibia* is in structure like the ordinary skeletal muscles, except for a greater tendency to branch; also, like the skeletal muscles, its motor nerves are paralyzed by curare.

the ventricles. Muscle-cells of this kind are found only in *warm-blooded animals (birds and mammals)*; (*B*) that in which the cells are fusiform, generally branched, and always much longer than broad, averaging about 100 μ long and 12 μ wide. Cells of this kind are found in all *cold-blooded vertebrates* (*reptiles, amphibia, and fishes*), and are often described, and sometimes figured as simple spindles, like the smooth muscle-cells (see below). Simple fusiform cells were rarely found by the writer. In many cases what appeared to be a simple spindle was found to have a branch on the opposite side when the cell was made to turn over; in other cases there were found places from which branches might have been broken.

Relations of the Cardiac Muscle-cells.—(*A*) In mammals and birds the cells are joined to one another in the most intimate manner, both by their ends and lateral branches, so that there results an anastomosing network with narrow meshes (Fig. 2396). Before Weismann's investigations it was supposed that the originally independent cardiac muscle-cells fused so as to make long branched, multinucleated, anastomosing fibres. It is now almost universally believed that, although the component cells are intimately united, a true fusion does not take place, for by suitable reagents they may be partly or wholly isolated, and where the isolation is incomplete the junction between the cells may in most cases be clearly seen. In

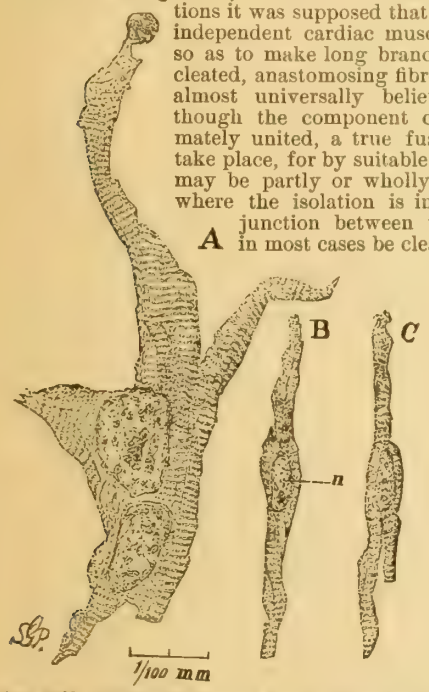

Fig. 2400.—Cardiac Muscle-cells from the Ventricle of *Necturus Lateralis*, to show the Various Forms of Cells and their Structural Details in a *Perennibranchiate Amphibian*. *A*, Large branched cell with two nuclei which contain numerous nucleoli. Near the end of the longest branch the regular transverse striation is replaced by irregularly arranged granules. Large cells like this are common in the heart of *Necturus*; they are plate-like, as was determined by a profile view; *B*, *C*, cells of approximately the same thickness as breadth; they form the great bulk of the heart, and usually are branched; *n*, nucleus with nucleoli.

newly-born mammals and newly-hatched birds the cells are readily isolated, and when seen in their natural relations they appear, in form and arrangement, like the cardiac muscle-cells of cold-blooded vertebrates (Fig. 2411).

(B) In cold-blooded vertebrates (reptiles, amphibia, and fishes) the cardiac muscle-cells are readily isolated, and while very few of the cells are simple spindles, there seems to be no approach toward fusion of neighboring cells. They lap, dove-tail, and interlace in the most varied manner, but are simply cemented together as are the smooth muscular fibres (see below). In all the cold-blooded animals examined cardiac muscle-cells are occasionally seen, which approach in shape those of birds and mammals, but they are not as broad as those of birds and mammals, and appear simply like ordinary branched or spindle-shaped cells, with the branches and ends broken off.

Sarcolemma.—This is supposed to be entirely absent from all forms of cardiac muscle-cells.

Sarcous or Contractile Substance.—This, as in the skeletal muscular fibres, has a distinct transverse and a less distinct longitudinal striation (Figs. 2397 and 2398). The intimate structure is supposed to be the same as that of the skeletal muscle. In some of the cardiac muscle-cells of cold-blooded vertebrates the striation is, in some cases, present in only part of the cell, the remainder appearing coarsely granular (Figs. 2400 and 2401).

Nuclei or Muscle-corpuscles.—Most cardiac muscle-cells possess but a single nucleus, which averages about 14 μ long and 7 μ wide in man, and 12 μ long and 5 μ wide in cold-blooded vertebrates. It is usually situated in the middle of the length and thickness of the cell, and parallel with its long axis. That the nucleus is imbedded in the sarcous substance is shown by sections (Fig. 2403),

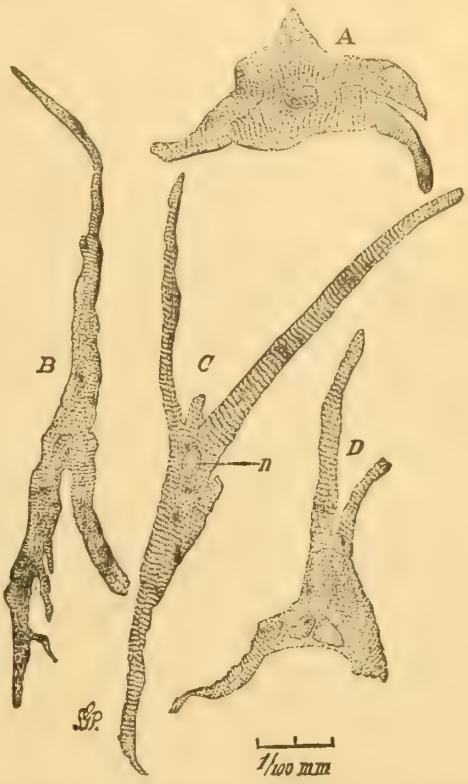

Fig. 2401.—Cardiac Muscle-cells from the Ventricle of a Toad (*Bufo Americanus*), to show the Various Forms of Cells and their Structural Details in an *Anourous Amphibian*. The striation is rather fine throughout, and toward the ends is, in many cases, replaced by irregularly arranged granules. *A*, *D*, Broad branched cells. Cells of this kind are plate-like, as was determined by causing them to roll over so that a profile view could be obtained; *B*, *C*, branched cells of approximately the same thickness as width. Both these cells would be nearly fusiform if the lateral branches were removed; *n*, nucleus. In *D*, two nuclei are present.

and also from the fact that when the cell is viewed from the side the transverse striations pass directly across the nucleus (Figs. 2399, 2409 to 2411). This is most marked in the thick cardiac muscle-cells of mammals and birds.

Blood- and Lymph-vessels of Cardiac Muscular Tissue.—The vascular supply of this tissue is very copious. The cardiac muscle-cells are enclosed in a parallelogrammic network of capillaries, and the rootlets of its veins are formed by the union of several capillaries at the same point. The larger veins possess valves in man and the higher mammals at least. The lymphatics are numerous and consist of passages and spaces in the intermuscular connective tissue (perimysium) which communicate with the sub-pericardial lymph-vessels.

Nerves of Cardiac Muscular Tissue.—Myelinic and amyelinic nerve-fibres and small ganglia are very numer-

ous in the heart. The fibres extend in every direction between the muscle-cells. The special mode of their termination will be discussed under Nerves (*q.v.*).

Smooth or Unstriated Muscular Tissue.—This is the contractile tissue in the animal body, composed of elongated, mostly uninucleated, fusiform cells or fibres, which are arranged in membranes, sheets, plexuses, or scattered bundles, in the various organs.

Fig. 2402.—Cardiac Muscle-cells from the Ventricle of a Young Alligator, to show the Various Forms of Cardiac Muscle-cells and their Structural Details in the Heart of a Reptile. *A*, fusiform cell; *B*, *C*, branched cells. These make up nearly the entire mass of the heart, very few being simple spindles like *A*; *n*, nucleus in which the nucleoli are very distinct.

Figs. 2399 to 2402 are at a uniform magnification of 500 diameters. The drawings were made with a camera lucida, and the finer details of structure were determined with a $^1/_{12}$ homogeneous-immersion objective, and added free-hand. (Drawn by Mrs. Gage.)

Distribution. — This tissue is present in many invertebrates and in all the classes of vertebrates. In man and most mammals it is found in the following situations: (A) *Throughout the alimentary canal:* (1) muscularis mucosæ; (2) muscular coats of the stomach and intestines, part of the œsophagus, and in the œsophageal accessory muscles; (3) as membranes or scattered bundles in the ducts of the salivary glands, in those of the pancreas and of the liver, in the intestinal villi, and in the gall-bladder. (B) *Respiratory organs:* in the trachea, bronchi, infundibuli, and, according to some authors, in the alveoli of the lungs. (C) *Urinary organs:* in the medullary portion of the kidney (Jardet [11]), in the calyces and pelvis of the kidney, in the ureter, urinary bladder, and urethra. (D) *The generative apparatus:* (1) *male*, in the dartos of the scrotum, epididymis, vas deferens, vesiculæ seminales and musculi ejaculatorii, prostate, Cowper's glands, and the corpora cavernosa; (2) *female*, in the ovary, Fallopian tubes (oviducts), in the uterus and all its ligaments, in the vagina, corpora cavernosa, in the nipples and the surrounding areolæ. (E) *Vascular system:* in the endocardium, semilunar valves, middle coat of almost all the blood-vessels and larger lymphatics, in the adventitia of some arteries and veins, and in some of the lymphatic glands. (F) In the capsule, and in many mammals also in the trabeculæ of the spleen. (G) *In the skin* in connection with the sweat and ceruminous glands, and forming the arrector pili. (H) *In the eye and its vicinity*, the *musculus orbitalis et palpebralis* of H. Mueller, in the orbital fissure and forming the ciliary muscle (tensor choroidæ or muscle of accommodation), the sphincter and dilator of the pupil.

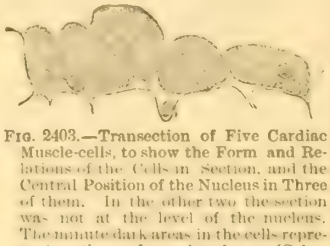

Fig. 2403.—Transection of Five Cardiac Muscle-cells, to show the Form and Relations of the Cells in Section, and the Central Position of the Nucleus in Three of them. In the other two the section was not at the level of the nucleus. The minute dark areas in the cells represent sections of muscle-columns (Cohnheim's areas). Magnified 550 diameters. (Ranvier.)

Constituents of Unstriated Muscular Tissue. — These are: (A) The contractile or muscular fibre-cells or fibres forming the essential elements. (B) Connective tissue forming a kind of perimysium which surrounds the muscular tissue and, penetrating between the fibres, combines them into bundles. (C) Blood- and lymph-vessels and nerves.

Relations of the Fibres.—The fibres forming a bundle or fascicle are cemented to one another throughout their entire extent, lapping and interlacing so that apparently solid bundles or membranes without fissures are formed (Fig. 2404). As a rule, there are no distinct tendons for unstriated muscular tissue, since in muscular membranes which entirely surround an organ, tendons would be unnecessary; and in other cases the close relations of the fibres to the surrounding fibrous tissue, and the commingling of its perimysium with the surrounding fibrous tissue, serves to connect the muscles to the part to be acted upon. In special and rare cases, tendons appear to be formed by the insertion of single unstriated fibres into the fork of an elastic tissue-fibre.

Intimate Structure of Smooth or Unstriated Muscular Fibres (muscular or contractile fibre-cells, smooth or plain muscular fibres or muscle-cells, non-striped or non-striated muscular fibres, unstriped or unstriated muscular fibres or muscle-cells, involuntary muscular fibres, fibre-cells, or muscle-cells). As stated above, smooth or unstriated muscular tissue is composed of special fibres or cells which form the essential and contractile part of the tissue. They are also its anatomical or structural elements, and are in general fusiform, sometimes branched, and usually contain but a single nucleus (Figs. 2404, 2407). The fibres vary greatly in size, ranging from 30 μ long and 4 μ wide to 230 μ long and 15 μ wide. In the gravid uterus they may attain a length of 500 μ. Those of the vascular system are usually smaller than those in other situations, and they are almost invariably of very irregular outline (Fig. 2406).

Fig. 2404.—To show the Form and Relations of Smooth Muscular Fibres in their Length and in Direct and Oblique Sections. From the human uterus shortly after delivery. Magnified 500 diameters. (Heitzmann.) *C*, capillary (the cut ends of two other vessels are shown in the figure); *Ct-c*, connective-tissue corpuscle, or plastid in the perimysium; *M-l*, smooth or unstriated muscular fibres shown lengthwise and in their normal relations to one another; *M-o*, ends of smooth muscular fibres cut obliquely; *M-t*, ends of smooth muscular fibres cut transversely; *P*, perimysium, or interstitial connective tissue.

Nucleus.—The nucleus is usually oval in outline (rod-shaped in those of the vascular system), and averages

about 15 μ to 20 μ long and 4 μ to 10 μ wide. It extends lengthwise of the cell, and often contains one or more nucleoli (Figs. 2404, 2406 and 2407). A complex intra-nuclear network has been described by recent authors. At each end of the nucleus there is in many cases a conical mass of granular matter; this is supposed to be protoplasm not yet differentiated into contractile substance.

Fig. 2405. — Transection of Part of the Muscular Coat of the Small Intestine, to show the Cut Ends of Smooth Muscular Fibres, and the Relations of the Fibres to One another; also, the Combination of Fibres into Fascicles. From a rabbit. Magnified 320 diameters. (Ranvier.) *c*, cement between neighboring fibres; *n*, nucleus. The nucleus shows in only a part of the fibres, as the section was not made at the level of the nucleus in all (compare Fig. 2404).

Contractile Substance of the Smooth or Unstriated Muscular Fibres.—In the fresh condition, and after many methods of preparation, the smooth muscular fibres appear homogeneous, except for a few scattered granules, the nucleus, and the slight amount of granular matter at its ends. Under favorable conditions of preparation and light, the body of the fibre appears no longer homogeneous but distinctly fibrillated, the fibrils extending parallel with the long axis of the fibre, and being therefore of varying length (Fig. 2407). They are very fine and appear like a skein of thread, being in many superimposed layers, and not in a single layer, as is shown in Fig. 2407. These fibrils are supposed to be the true contractile parts of the fibre. Between them is a limited amount of clear intermediate substance. According to some authors, the fibrils are directly connected with the intra-nuclear network.

Sarcolemma.—A thin, homogeneous, elastic sheath or sarcolemma is described by some authors as enclosing the individual smooth muscular fibres (Fig. 2407, B). An equal, or greater, number of authors deny the presence of a special envelope or sarcolemma for the smooth muscular fibres of vertebrates.

Blood- and Lymph-vessels of Unstriated Muscular Tissue.—The blood-vessels are less numerous than those of the striated muscles, but they have the same general arrangement, the capillaries forming a network with square or parallelogrammic meshes. The lymphatic vessels have been most investigated in the muscular tissue of the uterus and intestine, where they are in the form of passages and lacunæ which anastomose between the fibres.

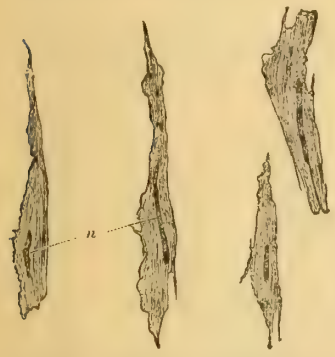

Fig. 2406.—Smooth or Unstriated Muscular Fibres of the Vascular System, to show their Irregular Form and the Rod-shaped Nucleus. From the thyroid artery of man. Magnified 340 diameters. (Schaefer.) *n*, Nucleus.

Nerves of Smooth or Unstriated Muscular Tissue.—These are abundant and consist of myelinic and amyelinic fibres, which are in many situations in the form of a plexus with ganglia. The special distribution to the individual muscular fibres, and the termination of the nerves, will be discussed under Nerves (*q. v.*).

Histogenesis of Muscular Tissue.—Muscular tissue of all forms in vertebrates is developed from cells of the mesoderm or middle germinal layer. The cells are at first rounded and indistinguishable from others of the mesoderm. It is only later, when approximately in the position of the future muscle, that they assume the characteristic form and appearance of the structural elements of the special kind of muscular tissue to which they give rise.*

Histogenesis of Striated, Skeletal Muscular Tissue.—The muscles of the trunk are without doubt mainly or entirely derived from special masses of mesodermal cells—*muscle-plates* or *myotomes* (*protovertebræ* of older writers). These appear on the dorsal aspect of the embryo, and give it the first appearance of being composed of a series of segments. According to some writers, all the skeletal muscles are derived from the muscle-plates, those of the limbs being outgrowths or diverticula of the muscle-plates. According to others, the muscle-plates give rise only to the muscles of the trunk and those of mastication, while those of the skull, limbs, and skin are derived from cells of the mesoderm, which have had no connection with the muscle-plates.

Cellular Origin of the Muscular Fibres.—All are agreed that the muscular fibres are derived from mesodermal cells; but there are two views as to the number of cells entering into the formation of a single muscular fibre. These are, (A) that they are *multicellular in origin.* This view originated with Schwann,[3] and is at present held by a considerable number of investigators. It teaches that each striated muscular fibre arises by the fusion of several cells arranged in a row, the nuclei of the fused cells remaining as the muscle-corpuscles. The entire fibre is therefore, according to this view, a multicellular structure or *cell-complex.* (B) That they are *unicellular in origin.* This view originated with Remak,[12] and is the one adhered to by most later writers. It holds that each striated muscular fibre originates from a single cell, the nucleus of which divides repeatedly with the growth of the cell. According to this view, the muscle-corpuscles are formed by the division of the original nucleus, and the entire fibre is an enormous *multinuclear cell.*

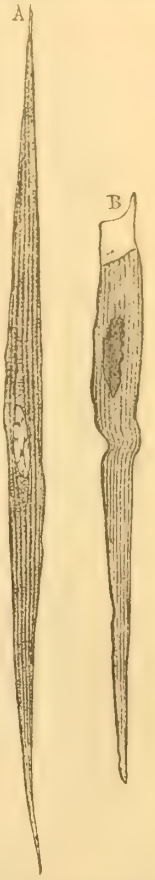

Fig. 2407.—Smooth, or Unstriated Muscular Fibres, to show the Fibrillated Structure and the Intra-nuclear Network. From the small intestine. Highly magnified. (Schaefer.) A, An entire cell or fibre, showing the fusiform shape, the longitudinal fibrillation, the oval nucleus with its intra-nuclear network, and the conical mass of granular protoplasm at each end of the nucleus. The fibrillæ appear coarse and as if in a single layer; in an actual specimen they are very fine and in many superimposed layers. B, a broken fibre, to show the presence of a sheath or sarcolemma projecting like a hollow sac from the broken end.

Whether the muscular fibres are of multicellular or unicellular origin, the later course of development is as follows: The elongated granular spindles, which are to become muscle-fibres, show first a faint longitudinal striation at the entire periphery or at one side, and later a transverse striation; or the two striations appear simultaneously. The nuclei and the unstriated protoplasm occupy the centre or one side of the fibre (Fig. 2408). Gradually the entire protoplasm becomes striated, and in birds and mammals most of the nuclei reach the surface of the fibre; but in the cold-blooded vertebrates they are scattered throughout its entire thickness. Glycogen is very abundant during the later stages of development.

Sarcolemma.—According to Schwann, this is formed by a union of the cell-walls of all the cells originating the fibre, the parts of the cell-walls which originally came in contact in the interior having disappeared. Others hold that this is the cell-wall of the single cell originating the fibre; and still others agree with Busk and Huxley, that in the earlier stages of development nothing like a cell-wall or sarcolemma is present, but that it is an after-develop-

* It is sometimes stated that each muscular fibre is a *modified epithelial cell.* This simply means that, as the muscular fibres are derived from the mesoderm, they may be considered as epithelial in origin, for the mesoderm forms a kind of epithelium, lining the cœlom or embryonic body cavity, before the muscles are developed (see article Fœtus, vol. iii.).

ment, and arises by a transformation of the protoplasm at the surface of the fibre into formed material or a kind of cuticula. The view of Busk and Huxley seems to be most in accordance with the general teachings of histogenesis and growth.

Growth and Regeneration.—After the muscular fibres acquire their characteristic appearance, they continue to increase in size until the animal has attained its complete development. They are said to have five times the diameter in the adult that they have in the newborn. It is at present uncertain whether the increase in size of an adult muscle is due simply to an increase in size of the individual fibres, or whether there is a development of new fibres, or whether it is due to both these causes. When a muscle is cut the interval between the cut ends is at first bridged by connective tissue, but later the connective tissue is replaced by muscular tissue which grows from the cut ends of the muscle. When a muscle wastes the exact process taking place is still undetermined. Some of the fibres may disappear entirely by fatty degeneration and subsequent absorption, or some of the fibres may decrease in size by a molecular process the converse of that of growth. The decrease may be due to a combination of both processes. When recuperation takes place, new fibres are developed within the muscle (Beale), or the number of fibres is increased by the longitudinal division of already existing fibres (Kölliker).

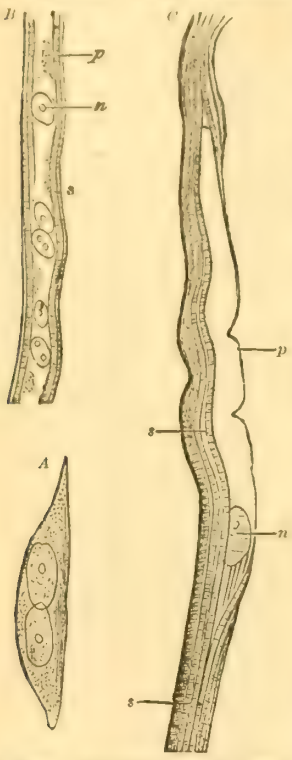

FIG. 2408.—Developing Striated Muscular Fibres, showing Different Stages of Development and Different Positions of the Unstriated Protoplasm. *A*, Elongated cell with two nuclei: the longitudinal striation is beginning to show on the right side. From a fœtal sheep (Wilson Fox). *B*, developing muscular fibre, showing both longitudinal and transverse striations at the periphery, and a central unstriated cylinder of protoplasm containing several nuclei. From a human fœtus near the third month (Ranvier).* *n*, Nucleus (there is usually a mass of glycogen near each nucleus); *p*, central unstriated protoplasm; *s*, peripheral striated substance. *C*, developing muscular fibre, showing a lateral position of the unstriated protoplasm. From a three months' human fœtus (Ranvier). *n*, Nucleus; *p*, unstriated protoplasm at one side of the fibre; *s*, striated sarcous substance with longitudinal and transverse striations.

Histogenesis of Cardiac Muscular Tissue.—The development of cardiac muscle seems not to have been followed through all its stages so closely as has that of the skeletal muscular tissue. It is known, however, that the cardiac muscle-cells are derived from the mesoderm, and at first are rounded in shape like the other mesodermal cells. In the first stage of development the cells become fusiform and granular, then longitudinal and transverse striations gradually appear until the entire cell is striated. The nucleus is large and centrally placed. Sometimes two or more nuclei are present.

Growth and Change of Form in the Cardiac Muscle-cells.—The individual cells increase greatly in size until adult life. In man they are about twice as long and three times as broad in the adult as at birth. The cardiac muscle-cells of mammals, during the last two-thirds of intra-uterine life, are fusiform and sometimes branched, and their general appearance and proportions are strikingly like those of reptiles and the other cold-blooded vertebrates, and they are as easily isolated. (Figs. 2399 to 2402, 2410 to 2411). The same is true of the cardiac muscle-cells of the newly hatched chick (Fig. 2409). The change in the proportions and the apparent fusion or semifusion of the cardiac muscle-cells of warm-blooded animals (birds and mammals) occurs mostly after birth, and is a stage of differentiation in advance of that attained by the cold-blooded animals. The divergence from the simple type begins before birth, especially in man, as was shown by a comparison between the cardiac muscle-cells of a fœtus at four to five months, and those of a child at birth. This comparison showed an increase of fifty-five per cent. in the width of the fibres and only forty-five per cent. in the length.

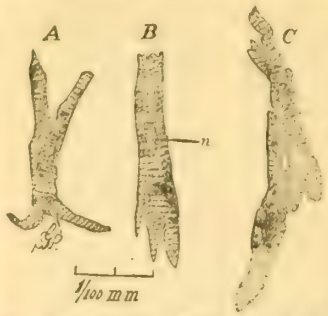

FIG. 2409.—Cardiac Muscle-cells of the Left Ventricle of a Newly-hatched Chick, to show the Form and Structure of the Cells, their General Appearance being like that of Adult Cold-blooded Vertebrates. *A*, Branched cell; *B*, cell with proportions nearly like those of the adult; *C*, two cells in their natural relations, the lower one is fusiform and the transverse striation obscure; *n*, nucleus. In all the cells the striations extend across the nucleus.

Fibres of Purkinje.—In the heart of many adult animals (especially ruminants; also in the heart of the pig, horse, dog, cat, hedgehog, marten, and some birds; also, according to Gegenbaur, sometimes in the human heart) there appear, in the muscular substance next the endocardium, chains or groups of cells with a granular, nucleated central part and a striated periphery (Fig. 2412). These cells are supposed to be cardiac muscle-cells in course of development into those of the ordinary, elongated, adult form, with branches and striation of the entire contents.

Histogenesis of Smooth or Unstriated Muscular Tissue.—The cells which develop into unstriated muscular tissue are derived mostly from the splanchnic layer of the mesoderm. The cells are at first rounded and granular; they elongate in two directions, thus forming the characteristic fusiform, smooth, or unstriated muscular fibres. The development of the longitudinal fibrillation has not yet been traced.

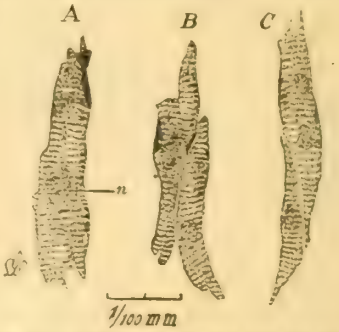

FIG. 2410.—Cardiac Muscle-cells from the Left Ventricle of a Kitten Three Weeks Old, to show the Form of the Cells, their Structural Details, and the Commencement of a Close Union between Two of them. *A*, Large cell possessing nearly the proportions of those of the adult. *B*, two cells in their natural relations; about opposite the nucleus of the upper one the cells are closely united as in the adult: compare Figs. 2396, 2401. *C*, two cells in their natural relations, the upper one has two nuclei. *n*, Nucleus. The transverse striations cross the nucleus in all the cells.

PHYSIOLOGY OF MUSCULAR TISSUE.—Physiologically, muscular tissue is characterized by its power of contracting in but one direction, and thereby giving rise to definite movements. In the contraction of the muscle it becomes shorter and correspondingly thicker, resembling in this respect a rubber cord which, having been stretched, is allowed to regain its original condition; that is, there is a shortening with a corresponding thickening, the volume remaining practically unchanged. The contraction or contractility of muscular tissue is simply a specialized form of the

* This figure is almost identical with the one of developing striated muscle published by Schwann [3] in 1839 (Pl. XIV., Fig. 3).

Muscular Tissue.

contractile power possessed by undifferentiated protoplasm.

Elasticity.—Muscular tissue is said to have slight but perfect elasticity, so that after a contraction its elasticity causes it to return to its original or passive form.

Irritability.—By the irritability of muscular tissue is meant the property by which its characteristic function—contractility—is brought into action by an outside influence called a *stimulus*. The normal stimulus to muscular activity is that given by the nervous system (nervous stimulus). Muscles may also be called into action by heat, cold, chemical and mechanical stimuli, and by electricity, the last-named closely simulating a nervous stimulus. Muscular tissue was for a long time supposed not to possess an independent irritability, but to be entirely dependent upon the nervous system; and that it could be called into action only by a nervous stimulus or by artificial stimuli acting upon its nerves. That the skeletal muscles possess independent irritability has been demonstrated by two crucial experiments: (A) When the nerve supplying the muscle in a living animal is cut and the peripheral end of the nerve stimulated, the muscle will contract; but after a time—the time varying in different animals—no muscular contraction will follow the stimulation of the nerve, although the muscle will contract vigorously when the stimulus is applied directly to it (J. Müller, 1834); (B) if the motor nerve of a muscle is paralyzed by curare, so that no contraction follows a stimulus applied to the nerve, the muscle will still contract vigorously when the stimulus is applied directly to it (Bernard, 1857). The independent

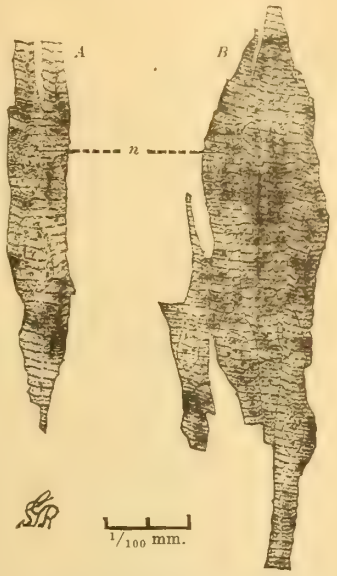

Fig. 2411.—Cardiac Muscle-cells of the Left Ventricle of a Child at Birth (Full Term), to show the Form of the Cells, their Structural Details, and their Relations to One another, and their General Agreement with those of Cold-blooded Vertebrates. *A*, large cell with two nuclei; this cell has nearly the proportions of those of the adult. *B*, group of cells in their natural relations; at the right of the middle cell are two spaces or fissures (compare Fig. 2396). *n*, Nucleus. The transverse striations cross the nuclei in all the cells, and each nucleus possesses several nucleoli.

Figs. 2409 to 2411 are at a uniform magnification of 500 diameters. The drawings were made with a camera lucida, and the finer details of structure determined with a 1/18 homogeneous immersion objective, and added free-hand. (Drawn by Mrs. Gage.)

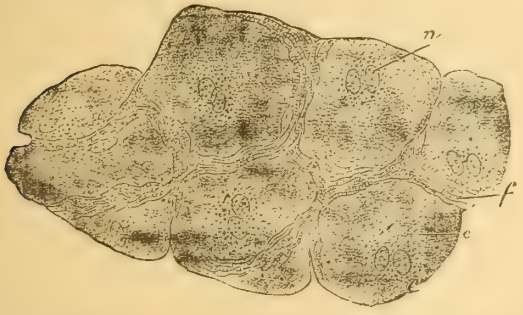

Fig. 2412.—Fibres or Cells of Purkinje from the Heart of a Sheep. Magnified 300 Diameters. (Ranvier.) *c*, Clear granular, central, unstriated protoplasm; *f*, peripheral striated substance · *n*, nucleus. There are usually two nuclei in each cell.

irritability of smooth muscular tissue is shown from the fact that where nerves are not present, as in part of the ureter, a contraction will follow a stimulus applied directly to the muscle.

The contractility and irritability of muscular tissue are dependent upon: (A) The supply of oxygenated blood; (B) the temperature, the activity being greatest at the maximum temperature not injurious to the muscle, and *vice versa*; (C) the absence of over-fatigue or exhaustion.

Glycogen and Hæmoglobin.—In all forms of muscular tissue glycogen is present in a greater or less amount. Its exact significance has not yet been determined. Hæmoglobin in a diffuse form, and independent of that in the blood, is present in certain situations in all forms of muscular tissue. It is supposed to serve as a kind of store-house for oxygen, but the matter requires further investigation.

Reaction of Muscular Tissue.—Resting or passive muscular tissue is neutral, alkaline, or amphicroitic (*i.e.*, turns red litmus paper blue and blue red), but during a contraction and shortly after, the muscle has an acid reaction.

Muscular Tonicity (*Muscular Tone, Tonic or Passive Muscular Contraction, Retractility*).—It has been held by many physiologists that muscles, when in a normal condition, and with their nervous connections intact, are, during apparent repose, in a condition of slight but constant contraction. A special tonic contraction is denied by other physiologists, who claim that all the phenomena attributed to tonic contraction are due to the elasticity of the muscles, and to the fact that the muscles are, during the passive condition, slightly stretched.

Physiology of Striated Skeletal Muscular Tissue.—The characteristic physiological property of striated muscle is its power of rapid and energetic contraction followed by a rapid relaxation. This tissue is in nearly all situations voluntary. That concerned in respiration and the second stage of deglutition, however, is only partly so, and that in the œsophagus of man is wholly involuntary.

Red and Pale Muscles.—It has been known for a long time that some muscles, independent of the blood in them, are red, while others are pale. Ranvier drew especial attention to this fact, and concluded from his investigations that there was a structural and physiological difference in them. In structure the red muscles, according to Ranvier, have distinct longitudinal and transverse striations, and act more slowly, like the cardiac muscle; while the pale muscles have a very indistinct longitudinal striation and a distinct transverse striation. Their action is rapid, and the relaxation follows the contraction almost immediately. Other observers have not been able to verify a constant difference of structure and function in the red and pale muscles.

Spasm and Tetanus.—If a single stimulus, like a shock from an electrical machine, be applied to a living muscle or its motor nerve, there follows almost immediately a single contraction, followed by a relaxation. Such a contraction is called a *spasm*. If suitable connections are made with a myograph, a tracing like that shown in Fig. 2413 will be obtained. An analysis of this *tracing*, or *muscle-curve*, shows that there is an interval following the application of the stimulus before the contraction begins. This interval (*a*, *b*, Fig. 2413) is called the *latent period*, and in man varies from 0.004 to 0.01 of a second. If the stimulus is applied directly to the muscular substance, the latent period is shorter than when it is applied to the motor nerve supplying the muscle. At the end of the latent period the contraction takes place rapidly, and almost immediately relaxation follows, with about the same rapidity. If a series of stimuli are applied to a muscle or to its motor nerve with sufficient rapidity—the number per second varying in different animals, being ten to twenty in the rabbit, and from three hundred to four hundred in insects—the muscle will not relax, but will remain contracted for a considerable time. Such a continuous contraction is called *tetanus*. In all the voluntary movements of the body the muscles concerned are for the necessary time in a condition of tetanus. It has been found also that the amount of the contraction,

as indicated by the height of the curve (Fig. 2413), depends, within limits, upon the strength of the stimulus. A stimulus giving rise to the greatest possible contraction of which the muscle is capable, is called *a maximal stimulation*. If a weak stimulus is applied to a muscle there will follow a contraction, and if, before the relaxation commences, a stronger stimulus is applied, the muscle will contract still more, and so on till the maximal stimulation is applied. Frog's muscle acted upon by a maximal stimulation may be shortened as much as eighty-five per cent. of the total length, and the volume of the contracting muscle has been found to decrease very slightly in volume (about $\frac{1}{200}$).

Contraction Waves, Rate of Transmission.—When a muscle contracts, the contraction passes in the form of a wave from the point of stimulation in both directions. It has been supposed that each fibre requires a separate stimulation. When a motor nerve of a muscle is stimulated this is probably the case, but when the muscle itself is directly stimulated at but one end, it does not seem probable that, in a muscle composed of more than a single length of fibres, each fibre throughout the whole length of the muscle could be stimulated. It is known that with smooth muscular fibres the stimulus is transmitted from fibre to fibre, and it does not seem improbable, from the intimate connection of the striated fibres which terminate within a muscle (Fig. 2388), that in a muscle composed of two or more lengths of fibres, the stimulus might be transmitted from one lapping fibre to

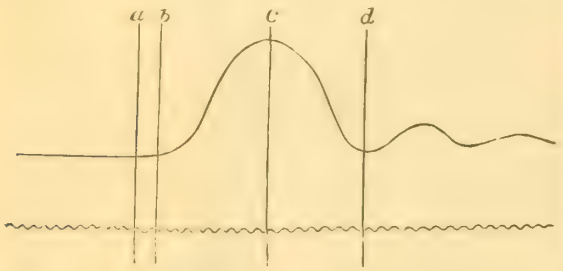

Fig. 2413.—Muscle-curve obtained by Means of the Pendulum Myograph, to show a Contraction or Spasm due to a Single Stimulus. To be read from left to right. Foster: *a*, Indicates the moment when the stimulus is applied; *b*, the beginning; *c*, the maximum, and *d*, the close of the contraction. "The two smaller curves succeeding the larger one are due to the oscillations of the lever." The time, *a*–*b*, that is, the time between the application of the stimulus and the beginning of the contraction, is known as the *latent period*. "Below the muscle-curve is the curve drawn by a tuning-fork making one hundred and eighty double vibrations a second, each complete curve representing, therefore, $\frac{1}{180}$ of a second." By an error in reproducing the engraving the curve of the tuning-fork during the latent period, *a*–*b*, is represented by a single, large, downward curve, instead of two upward curves of the same size as the others.

another. The length of a contraction wave in a muscle in its normal condition and relations is 200 mm. or more, and is always greater than the length of the individual fibres composing the muscle, and therefore an entire muscular fibre is in contraction at once. The rate of the transmission of the wave in rabbit's muscle removed from the body is from four to five metres per second, in frog's muscle three to four metres, in the muscles of a living man ten to fifteen metres. Short contraction waves, involving but part of the length of a fibre (Fig. 2414), are probably never present when the muscular tissue is in its normal conditions and relations in the body.

Work and Heat.—When a muscle contracts under normal conditions, it usually performs work by moving some part of the body, and at the same time there is developed a certain amount of heat. It is found, broadly speaking, that in accordance with the law of the *correlation and conservation of energy*, the amount of work and heat vary inversely, so that when the most work is done with a given amount of muscular activity, the least heat is developed, and *vice versa*. In cases of pathological tetanus, where very little work is done, the heat is often considerable, being sufficient in dogs, when all the muscles are kept tetanized by electrical stimulation, to raise the body temperature to forty-four or forty-five degrees Centigrade.

Laws of Muscular Work.—(A) The greater the transverse section of a muscle, the greater the weight it can lift; (B) the longer the muscle—if its fibres are parallel—the higher it can lift a weight; (C) a muscle can lift the greatest weight at the beginning of a contraction; (D) when a muscle is loaded with a weight which it is just unable to lift under a maximal stimulation, it is said to exert its *absolute muscular force*; under these conditions the greatest amount of heat is produced; (E) the muscular metabolism varies directly with the amount of work and heat; (F) a greater weight can be raised by a tetanic stimulation than by a single maximal stimulation.

Amount of Work.—This varies greatly in different animals. Some insects can draw sixty-seven times their own body weight, while a horse can draw only about three times its body weight. A man can carry double his weight, a woman about the half; boys can carry about a third more than girls. The total amount of work performed by a man in eight hours rarely exceeds three hundred thousand kilogram-metres.

Chemical Changes Occurring in an Active Muscle.—(A) The muscle ceases to be neutral, alkaline, or amphicroitic, and becomes distinctly acid, by the formation within it of sarcolactic acid; (B) carbon dioxide is always given off, but there is no definite relation between the amount of carbon dioxide given off and the oxygen taken up during muscular activity; (C) under normal conditions an increased amount of oxygen is taken up by an active muscle; but the activity is not dependent on the presence of free oxygen, since a muscle will contract in a vacuum, or in an atmosphere containing no oxygen; (D) the extractives soluble in water decrease, those soluble in alcohol increase; (E) in some cases there is a diminution of glycogen, and an appearance of a peculiar muscle sugar; (F) the amount of nitrogenous waste is slightly increased after muscular exertion. At present the chemical changes taking place in a muscle are not sufficiently understood, and the waste of either carbo-hydrate or nitrogenous material does not seem sufficient to enable physiologists to point with certainty to the food-source of muscular power. The activity of muscular tissue is no doubt due to a breaking up in the muscle of some complex compound (*inogen*), which can be formed only by the living muscular substance. Excepting oxygen, the special food constituents entering into this specific contractile material are not known.

Physical Changes in Active Muscle.—A resting muscle in a perfectly natural condition is isoelectric, but during a contraction undoubted electric currents (*currents of action*) are developed. A current of action is developed in the part of the muscle which is getting ready to contract, this part becoming negative to the resting part of the muscle. The negative condition lasts only during the latent period, and travels along the muscle from the point stimulated just in advance of the wave of contraction. In muscles removed from the body, in which the muscular substance is cut or injured, there are present, during the passive condition of the muscle, the so-called *currents of rest*, in which the cut or injured part of the muscle is negative to the uninjured. By some authors the currents of rest are supposed to be present also in uninjured, passive muscle, but their presence is denied by many others.

Muscle Sound (Muscular Murmur).—Whenever a muscle contracts naturally in the body, the contraction is accompanied by a sound produced by vibrations occurring 19.5 times per second. The tone so produced cannot be heard by most persons. But what is actually heard is the first over-tone, corresponding to thirty-six to forty vibrations per second. The tone given by an artificially stimulated muscle corresponds to the number of stimuli received per second, showing that there is a vibration of the muscle for each stimulus. In a single twitch, or spasm, there is but a single vibration of the muscle and no sound is produced, and as the muscles contracting naturally in the body do give a sound, they must be in a

condition of vibration due to a series of stimuli; in other words, they are in a condition of tetanic contraction.

Optical Appearances of Striated Muscle during a Contraction.—When a muscular fibre in its normal relations in the living body contracts, the wave of contraction is so long that the entire fibre is involved at the same instant, and appears simply to shorten and thicken as does a stretched rubber cord, when it is able to overcome the resistance. When, however, a muscular fibre is removed from the body and isolated from its connections, the waves of contraction, when present, do not involve the entire length of the fibre, and sometimes but part of its width. As these waves pass slowly when the fibre is nearly dead, the changes taking place are more easily observed, and are often assumed to be the same as those occurring under normal conditions. In order that the changes may be carefully and continuously studied, the fibres are fixed by osmic acid, absolute alcohol, etc., during a contraction, producing the so-called *fixed waves of contraction*. The descriptions of the waves of contraction in a living fibre, and in one fixed as described above, are conflicting, and when compared, do not seem to throw much light on the intimate changes taking place in the fibre during a contraction. According to Schaefer, the heads of the dumb-bells (Fig. 2414) approach so closely that they appear fused and cease to produce a halo (see above). As the heads of the dumb-bells are dark, there appears in the place of the original light disk a dark one (Figs. 2414, 2415), while the dark disk, by contrast, appears light (this appearance is sometimes called the reversal of the disks). According to Engelmann, and many others, the changes during contraction, as determined by a study of the fibres in which waves of contraction were fixed as described above, are as follows: At the beginning of the contraction, the various disks appear by ordinary light of nearly a uniform tint (Fig. 2415, B), the so-called homogeneous stage. At the height of the contraction there appears to be a reversal of the disks. In polarized light there appears no such reversal, the light and dark disks looking as in the resting fibre, except in shape.

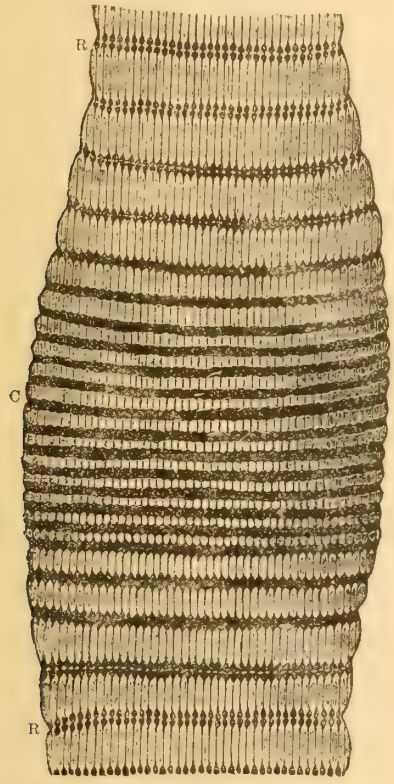

Fig. 2414.—Short Piece of a Striated Muscular Fibre of *Dytiscus*, showing Schaefer's Muscle Rods or Dumb-bells, and a Wave of Contraction involving but a Small Part of the Length of the Fibre. Highly magnified. C, Part of the fibre undergoing contraction; R, R, portions of the fibre at rest. (Schaefer.)

Physiology of Cardiac Muscular Tissue.—The physiology of cardiac muscular tissue, isolated from its connections, has not been worked out. It agrees with the other forms of muscular tissue, however, in being elastic and irritable. Its contraction and relaxation are rapid, but not so rapid as in the skeletal muscles. According to some physiologists, it can be tetanized, but according to others it cannot. If the theory is correct that the muscle-sound is due to the vibrations of a muscle in a tetanic contraction, then if any part of the heart-sounds is due to a muscular sound, it would follow that the heart also contracts tetanically.

Physiology of Smooth or Unstriated Muscular Tissue.—Like the other forms of muscular tissue, the smooth or unstriated is characterized by contractility and elasticity. The tissue is irritable, but the period (latent period, Fig. 2413, *a*, *b*) following a stimulation is very long (two to five seconds); the contraction is slow, and the relaxation even slower than the contraction. The shortening, however, is greater than with the skeletal muscles. The wave of contraction passes slowly (20 to 30 mm. per second), that is, only $\frac{1}{100}$ to $\frac{1}{600}$ as rapidly as in the skeletal muscles. The movement of smooth muscular tissue in many situations is rhythmical, and when the wave of contraction is propagated in the normal direction, as from the stomach toward the large intestine, it is said to be *peristaltic*; if the wave extends in the opposite direction, as from the large intestine toward the stomach, it is said to be *antiperistaltic*. It has been repeatedly shown that when a stimulus is applied at any intermediate point, as in the middle of the small intestine, the wave of contraction is propagated in both directions from the point stimulated, showing that the starting-point of the wave depends on the place of stimulation, and not on any special arrangement of the muscular fibres. It is supposed, also, that the stimulus is commu-

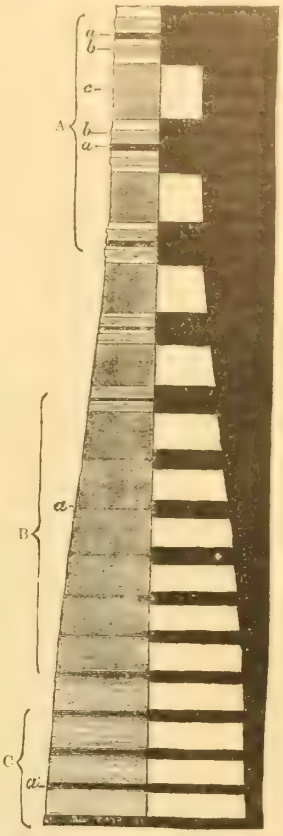

Fig. 2415.—Diagram of a Muscular Fibre of an Insect; during Rest (upper part), and Contraction (lower part); in Ordinary Light on the Left, and in Polarized Light on the Right Side. Magnified. (Engelmann.) A, portion of the fibre at rest; *a*, intermediate disk; *b*, accessory disk; *c*, dark disk. In polarized light the dark disk appears bright, showing that it is anisotropic, or doubly refractive, while the entire segment between two dark disks (the light disk) appears dark, showing that it is isotropic or singly refractive. (See Fig. 2393 for the nomenclature of the different disks.) B, appearance of a fibre at the beginning of a contraction (the so-called *homogeneous stage*). In ordinary light the entire fibre appears of a nearly uniform tint, but in polarized light the dark disk appears white, showing that it has not lost its anisotropic character during the change in form; while the light disk remains dark, showing that it is still isotropic. C, part of the fibre at the height of contraction. In ordinary light the dark disks appear light in contrast to the light disks, which are very dark. This is the so-called reversal of the disks. In polarized light the dark disks appear bright as before, and the light disks dark, as in a resting fibre. There is also shown very markedly the shortening and broadening of the light and dark disks, the shortening of the light disk being more marked than that of the dark disk.

nicated from fibre to fibre, it not being necessary, from the intimate relations of the fibres, that each fibre should be separately stimulated, as with striated muscular tissue. With the smooth as with the skeletal, muscular tissue, a single shock produces a spasm or single contraction, while a series of shocks produces tetanus.

Voluntary Smooth Muscular Tissue.—While most of the smooth muscular tissue is wholly involuntary, that in some situations seems to be directly or indirectly under the control of the will, although under ordinary circumstances its action may be reflex. In this category comes the smooth muscular tissue of the rectum and urinary bladder. There is difference of opinion, however, as to the voluntary action of the urinary bladder and rectum, but there is no doubt that the mechanism for the accommodation of the eye is voluntary.

Rigor Mortis (*Rigor, Rigidity, Cadaveric Rigidity, Death Stiffening*).—All forms of muscular tissue, after systemic death or removal from the body, or after cutting off the blood-supply in the living body, show sooner or later a stiffening or rigor. As muscular tissue becomes rigid it (A) contracts, (B) becomes opaque, (C) loses most of its elasticity, (D) gives an acid reaction, (E) gives off carbon dioxide, (F) develops heat, and (G) there appears in it a peculiar proteid substance (*myosin*).

In animals dying without fatigue, rigor comes on slowly and lasts a long time. In an animal dying after severe exertion the onset of rigor is rapid and lasts but a short time. In man rigor commences in from ten minutes to thirty hours, the average time being from four to seven hours, and lasts from one to six days, the average time being from twenty-four to thirty-six hours. In a human fœtus dying before the seventh month rigor does not appear.

There is a certain similarity and correlation between rigor and the normal activity of muscular tissue. The similarity consists in the contraction of the muscle, its acid reaction, the development of heat, and the giving off of carbon dioxide. As commencing rigor may be made to disappear by supplying the muscle with oxygenated blood, it is supposed by many physiologists that the initial stages of rigor and a normal contraction are the same, but that in the living body the muscle is repaired before it passes into true rigor. The correlation between rigor and normal contraction is shown by the fact that the amount of carbon dioxide given off by a muscle during rigor depends upon the previous activity of the muscle. It would appear that, starting from a state of rest, for example, a muscle possesses a definite amount of contractile material (*inogen*), whose decomposition is capable of giving rise to a certain amount of action and the liberation of a definite amount of carbon dioxide. As there is a definite amount of the contractile material, so much of it as is used up in normal contraction before systemic death does not, of course, remain after death to produce contraction, heat, and carbon dioxide in rigor mortis.

Muscular Sense.—By this is meant the information conveyed by the sensory nerves of the muscular fibres, the tendons, and joints to the central nervous system, concerning the activity taking place in the muscular tissue, and also the particular muscles that are acting. This sense is present in the skeletal muscles, but whether it is also present in cardiac and smooth muscular tissue has not yet been clearly determined. The information given by this sense serves three purposes: (A) It enables the motor nervous apparatus to furnish the appropriate stimuli for the muscular activity required to overcome the resistance in each case; (B) it aids the individual in estimating the amount of movement and its direction in space; (C) it indicates a condition of fatigue whenever it is present in a muscle. Muscular sense is a most important adjunct to the other senses, especially to the sense of sight, enabling one to judge with the greatest accuracy whether a line is exactly vertical, horizontal, straight or wavy, regular or irregular, as in following the line with the eye there is brought into play the necessary muscles to give the eyeball all the directions taken by the line, or the object whose outline is being examined. For determining the amount of pressure or weight of an object resting on any part of the body, the tactile sense gives most of the information, but when the weight is to be determined accurately the object is lifted or "hefted," and the muscular sense enables one to judge with far greater niceness of the weight than can be determined by simple pressure alone. Muscular sense is one of the most fundamental of all the senses. It often acts with the others, but is independent of them. It is most nearly associated with tactile sensibility, but is independent of it, as is shown by the fact that in some forms of ataxy the tactile sensibility is unimpaired, and also that, in some cases in which tactile sensibility is absent, the muscular sense is unimpaired (Foster).

Methods.—Isolation of the structural elements for all forms of muscular tissue was accomplished by soaking the tissue from one to three days in a mixture of 23 c.c. of concentrated nitric acid, and 77 c.c. of water, and then for a day or more in water, thirty-five per cent. alcohol or fifty per cent. glycerine. For cardiac muscle, soaking in a mixture of 40 grams caustic potash and 60 c.c. water for fifteen to sixty minutes, proved more satisfactory for isolation than the acid. Cardiac muscle must be perfectly fresh in order to obtain satisfactory results.

Acid specimens were mounted permanently in a mixture of glycerine, 75 c.c.; picrocarmine solution, 25 c.c. Permanent preparations of the caustic potash specimens were obtained by neutralizing the isolated cells with a drop of glacial acetic acid, and then mounting in strong acetate of potash, or in the glycerine mixture named above. For the fibrillation of the smooth muscular fibres, a piece of the perfectly fresh muscular coat of the small intestine of a cat was kept from one to three days in 100 c.c. of twenty-five per cent. alcohol, containing three-fourths of a gram of picric acid. Preparations were mounted in seventy-five per cent. glycerine. Serial sections were made to determine the relations of the striated muscular fibres to one another throughout the entire length of a muscle, and to determine the relative size and number of the fibres in a fascicle at different levels.

(For the general methods of histological investigation, the reader is referred to the article on Histological Technique, vol. iii., and to Microscopy, Clinical, in vol. iv.)

Bibliography.—The bibliography of muscular tissue is so extensive that it would be out of place to give it all in a work of reference like the present. For a more complete discussion of special points, and for the bibliography, reference may be made to the following: *Human Anatomy:* Allen, Gray, Quain; *Histology:* Frey, Heitzmann, Klein, Kölliker, Leydig, Prudden, Ranvier, Satterthwaite, Stowell, and Stricker; *Histogenesis:* Besides the above, the works on embryology by Balfour and Kölliker; *Physiology:* Brücke, Dalton, Ferrier (Functions of the Brain), Flint, Foster, Gamgee (Physiological Chemistry), Hermann, Landois, Martin, Milne-Edwards, Rosenthal (Phys. of Muscles and Nerves); Richet (Phys. des Muscles et des Nerfs); Sanderson (Handbook Phys. Lab.), Sully (Psychology); Yeo; special papers in the publications of learned societies and in periodicals, as in the Comptes Rendus of the French Academy, Denkschriften und Sitzungsberichte of the Vienna Academy, The Philosophical Transactions of the Royal Society of London, Arch. f. Anat. und Phys., Arch. Gesammte Phys., Arch. für Path. Anat. und Phys., Arch. für Mikr. Anat., Jour de l'Anat. et Phys., Jour. of Anat., Jour. of Phys., Quarterly Jour. Micr. Soc. The bibliography is especially good in the works of Gamgee, Kölliker, Quain, Satterthwaite, Stricker, and in the German periodicals and publications of societies. For the current literature of the subject the following, taken together, furnish nearly a complete record: Anatomischer Anzeiger, Index Medicus, Jahresberichte über die Fortschritte der Anatomie und Phys., Jour. Royal Microscopical Society, Zoologischer Anzeiger. *Simon H. Gage.*

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MUSK (*Moschus*, U. S. Ph., Br. Ph., Ph. G.; *Musc*, Codex Med.). "The dried secretion from the preputial follicles of *Moschus moschiferus* Linn.; Order, *Ruminantia*." This little animal, the so-called musk-deer, is a slender-limbed, active, and very timid inhabitant of the mountain regions of Central and Northern Asia. In its general shape it resembles a young deer. It is sixty or eighty centimetres long (from two to three feet), from forty to sixty in height, with the rump higher than the shoulders, of a grayish or blackish-brown color, with long, slender ears, large dark eyes, and two long, curved tusks projecting downward from the upper jaw. The secreting organ containing musk is a large, simple sac, situated in the median line just beneath the skin of the abdomen, in front of the preputial canal (of the male, it does not exist in the female), with which its posterior wall is connected. It is of a round or oval, plano-convex shape, six or seven centimetres in its longest diameter, and one or two or more thick. Internally it is incompletely divided by folds and partial partitions reflected from the wall. The orifice, often double, is situated over its middle, and is one or two millimetres in diameter. Its position is easily determined from the outside, because the hairs converge toward it and fairly grow within it. In the living animal the secretion contained in the gland is a soft-solid, not much thicker than honey, of a brownish-red color, and of a most intense, offensive smell. As it dries it darkens, becomes greasily brittle, and less odorous.

The musk-deer is laboriously hunted in the central and northern provinces of China, in the countries to the north of India, and in Siberia—in short, over a very extensive portion of Central Asia—for its skin and musk-glands. These "pods," as they are called, are cut out as soon as the animal is killed, and dried, often with the aid of artificial heat, when they are ready for the market. In this condition they are flattish, shrivelled pouches, covered on one side with hairy skin, in the centre of which is the orifice; the other side has the black appearance of dried meat. The contents are dryish, crumbly, breaking as they are turned out into coarse fragments (called grains), of an almost black color and penetrating odor. The very high cost of musk has led to numerous ingenious methods of adulteration; stones and other heavy minerals, hair, dried blood, fæces, etc., may be introduced through the natural opening; sometimes the sac is split and emptied, and then filled and dexterously sewed up again, with a mixture containing but little musk, or that of an inferior quality, as Siberian for Tonquin. Or the musk itself, when sold in grains, may be tampered with in similar ways. Sometimes artificial pods are made and filled—the scrotum of some animal is used, or a bag is made entirely *de novo* from skin, with a bladder, or some other membrane, for the back. The geographical source is important in determining the quality of musk; that of China and its tributaries is the most fragrant and best. Its pods are rounder, of more uniform shape, and its grains more odorous and larger. That from the north of India comes in irregular sacs, and that from Siberia in larger and longer ones. The following are the characters of musk as given by the Pharmacopœia: "In irregular, crummy, somewhat unctuous grains, dark reddish-brown, of a peculiar, penetrating and persistent odor, and bitterish taste. It is contained in oval or roundish sacs, about one and a half to two inches (four to five centimetres) in diameter, on one side invested with a smoothish membrane, on the other side covered with stiff, appressed, grayish hairs, concentrically arranged around two orifices near the centre. About ten per cent. of musk is soluble in alcohol, and about fifty per cent. in water."

Composition.—Musk is a very complex substance, and consists chiefly of common animal tissues and secretions. The following synopsis is from Hager's "Pharmaceutische Praxis:" *Fats, cholesterin, urea, biliary matters, mucus, albumen;* besides traces of *lactic, butyric, phosphatic, sulphuric*, etc., *acids;* traces also of *ammonia*, and a *volatile oil*. The odorous principle has never been separated. It is supposed to be formed by the gradual decomposition of some of the other constituents.

Action and Use.—This substance was for centuries the leading antispasmodic, and was, during most of this time, much more highly esteemed in medicine than it is at present, and given for numerous diseases involving disturbance of the nervous or mental faculties, hysteria, epilepsy, mania, etc., in common with several other odorous animal secretions—civet, castor, etc.—than which it is, to say the least, far less disgusting. Its high cost and impressive odor made it well adapted to hysterical outbreaks, for which it has some undoubted value. As it is, however, in these cases merely a palliative, and as there are now a dozen or more remedies that are more certain and far cheaper (a single dose of musk, which might be repeated several times a day, costs two dollars or more), musk as a medicine is fairly out of use. It can, however, be given, if desired, in doses of about a gram (grs. xv.) in pill or emulsion. A tincture (*Tinctura Moschi*, U. S. Ph., strength $\frac{1}{10}$) is official and may be used, but is mostly employed as a basis of perfumery, where the persistent or "staying" qualities of Musk make it of the greatest value.

The odor of Musk is considerably diminished by fennel, ergot, tannin, sour fruit juices, and some other things. Mixed with sugar it keeps very well.

Allied Animals.—This little animal is the only one of its genus. Deer, antelopes, gazelles, and other ruminants are distantly related to it. Some of these have odorous secretions of value. The fæces of an African antelope, *Antilope Dorcas* Linn., have a strong musky odor, and have been collected for use and even given to a hysterical patient! A number of rodents have a musky odor, our musk-rat for instance.

Allied Substances.—The principal animal, antispasmodic, and stinking secretions are Civet, from corresponding pouches of the civet cat, *Viverra Zibetha* Linn., of Asia; Castor, from the beaver, *Fiber Castor;* Ambergris, from the sperm-whale, *Physeter macrocephalus*. The pungent liquid ejected by the skunk is physiologically of the same origin and character. The vegetable antispasmodic stimulants, asafœtida, valerian, etc., appear to fully take the place of musk in medicine. *W. P. Bolles.*

MUSTARD (Black: *Sinapis nigra*, U. S. Ph.; *Semen sinapis*, Ph. G.; *Moutarde noire*, Codex Med. White: *Sinapis alba*, U. S. Ph.; *Moutarde blanche*, Codex Med. *Sinapis*, Br. Ph., includes both kinds mixed).

1. *Brassica nigra* Koch, *Sinapis nigra* Linn., is a tall, erect annual, a metre or less in height, with slender, wandering branches. Leaves dark green, smooth, generally glabrous, petiolate; the lower lyrate, the upper more or

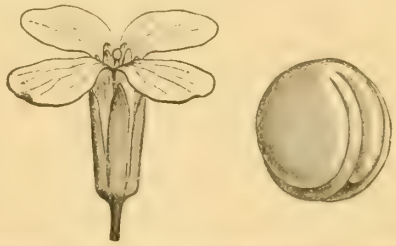

Fig. 2416.—Flower and Fruit of Brassica Nigra. (Baillon.)

less irregularly lobed; edges obscurely serrate. Inflorescence consisting of spikes, blossoming near the ends, and elongating as the closely appressed fruits develop below. Flowers small, less than a centimetre in diameter, yellow, cruciform. Fruit a short silique, terminated by a pointed beak, the whole about two centimetres long. Seeds eight or ten in each pod; globular, about a millimetre in di-

ameter, dark reddish-brown, and finely pitted on the surface; inodorous when dry, exceedingly pungent when moistened and broken. The nucleus consists of a large globular embryo, entirely filling the shell, folded so that the radicle lies at the back of one of the cotyledons, both of which are folded around it. Black mustard grows as a native on river-banks of Europe (excepting the northern portion), Northern Africa, and throughout Central and Southern Asia. It is widely cultivated for its seeds, which, with those of the next described plant, are a common table-condiment, and is naturalized in this country as well as in most others.

2. *Brassica alba* Hooker, *Sinapis alba* Linn. (Luerssen separates them into two genera—*Brassica nigra* and *Sinapis alba*), is a smaller plant than the preceding, with larger flowers, longer, spreading, but fewer-seeded pods, and a generally rough and hispid surface. Valves of the siliques three-nerved. Seeds two or three times as large as those of black mustard, with yellowish, finely pitted surface. Structure and other properties similar, but the taste and odor are milder. Habitat and cultivation same as the above.

Both black and white mustards were well known in ancient Europe, and employed indiscriminately both as a seasoning for food and as medicine.

Composition.—The constituents of the two varieties of mustard, although presenting close relationships, are not exactly identical. They both agree, however, in containing a considerable amount of a bland, light-colored, non-drying *fixed oil*—a mixture of the glycerine combinations of *oleic*, *stearic*, and *erucic acids*; in white mustard oil *benic acid* is also found. This oil amounts to about twenty-two or twenty-three per cent. of the seeds. The most remarkable constituent of black mustard is the crystalline, bitter-tasting, inodorous glucoside, *myronate* of *potassium*, or *sinigrin*; soluble in water, but not in alcohol or ether, and in its watery solution decomposing, in the presence of various ferments, especially of one to be mentioned below, into glucose, bisulphate of potassium, and the horribly acrid, sulphuretted, *essential oil* of *mustard* (iso-sulphocyanate of allyl, etc.), to which mustard is indebted in part for its medicinal value. This oil is not present in the dry seeds or their powder, but only produced when they are moistened. The development of the odor upon wetting mustard-flour is very evident. The albuminous ferment which assists in this decomposition is called *myrosin*, and is common to both kinds of mustard.

The glucoside in white mustard, resembling the sinigrin of the black, has been correspondingly named *sinalbin*, a neutral crystalline substance, soluble in cold water, and decomposed in a similar way as sinigrin into *sugar*, *sulphate of sinapin*, and *sulphocyanate of acrinyl*, the latter corresponding to the essential oil of the black mustard; it is an acrid and vesicating substance, but much milder than that of the black variety.

To bring out the full percentage of the black-mustard oil, an additional amount of myrosin to that contained in this drug is desirable, and is obtained by judiciously adding a certain quantity of the white mustard. The flour from this mixture is the strongest and best that can be made. That obtainable in our market is often the flour of white mustard only, and is generally more or less adulterated besides.

An oil exactly resembling that of black mustard has been made synthetically and is in the market.

Action and Use.—Both sorts of mustard-seeds possess the same qualities, varying only in degree of pungency; the black being the stronger. Swallowed whole they do not disintegrate much, but pass through the digestive tract. In this way white-mustard seed, particularly, is now and then given, in doses of a teaspoonful (three or four grams), for dyspepsia, constipation, etc.; like nearly everything else, it has also been employed in chronic cases of bronchitis, rheumatism, and some skin diseases for which there seems to be no rational indication. Its rare use at present for these purposes shows its slight value.

Ground mustard, white, black, or mixed, is an active local irritant as soon as wet with water so as to produce the acrid decomposition-products of the drug. The black variety is far more irritant than the white. Applied to the skin, it is quickly and painfully rubefacient; and if in contact with it long, vesicant—producing a crop of fine, deep, eczematous blisters, easily ruptured and very painful; the denuded surface following their rupture heals rather slowly. Internally, mustard, in small doses of two or three decigrams, is an aromatic stimulant, and as such is in every-day use at the table. In larger quantities, ten or fifteen grams, it is a prompt and valuable emetic, usually coming up in from two to five minutes after being swallowed. On this account, and because it is almost always at hand in the house, it is the most valuable emergency emetic at our command. For opium or other narcotic poisoning it is almost without an equal.

Administration.—The employment of whole mustard has been noticed sufficiently above. The ground mustard in use in this country is that sold by grocers for family use, and is seldom, if ever, a plain mixture of the two sorts of seeds and nothing else, which gives the most perfect product. It is oftener ground white mustard alone, and oftener still mustard diluted with a varying amount, generally considerable, of inert yellow powder. It is therefore subject to considerable variation in strength. This is used both internally and externally—internally, as a stimulant (condiment) and emetic; externally, always as a rubefacient. For an emetic, from a dessert- to a tablespoonful should be given, as a less amount may fail to produce vomiting and cause considerable gastric distress. Externally, it is chiefly employed in foot-baths and sinapisms—for the former, from one to two tablespoonfuls may be added to a small tub- or bucket-ful of warm water; for the latter, the mustard-meal is simply mixed with a little water and spread upon a cloth, or it may be diluted with meal or flour to reduce its strength. In this way mustard is the most widely used local remedy for the sudden and intense pain or distress of pleurisy, colic, some neuralgias, etc. It is also used as a derivative in nervous vomiting, cerebral and spinal inflammations, etc., and in many other conditions when acute attacks of pain are present. Both kinds of mustard are greatly damaged, or even spoiled, if mixed with hot water, as this destroys the ferment which brings out the active decomposition-principles. The following preparations are officinal: *Charta Sinapis*, U. S. Ph., made by taking ground Black Mustard, exhausting it of its fatty oil by percolation with Benzin, then mixing it with enough solution of Gutta-Percha to make a paste, and spreading it upon paper. This mustard-paper is almost never made by the dispensing apothecaries, since several manufacturers here and in France make excellent substitutes for it that can be easily obtained and carried everywhere. The activity of the mustard-paper is not developed until it is moistened in cold or merely warm water.

Oleum Sinapis Volatile, U. S. Ph. The Oil of Black Mustard is also officinal. It is obtained by grinding and macerating Black Mustard, or a mixture of both kinds, in water and distilling. It is "a colorless or pale yellow liquid, having a very pungent and acrid odor and taste, and a neutral reaction. Sp. gr., 1.017 to 1.021. It boils at 148° C. (298.4° F.). It is freely soluble in alcohol and in ether." Its odor when concentrated is frightful, causing lachrymation and intense pain in the nose. Applied to the skin, it blisters severely. Diluted with nine parts of alcohol, it causes, when rubbed upon the temples or forehead, a sharp temporary tingling that occasionally relieves mild headache. The Compound Liniment of Mustard (*Linimentum Sinapis Compositum*, U. S. Ph.) contains:

Volatile oil of Mustard	3 parts.
Extract of Mezereum	2 parts.
Camphor	6 parts.
Castor-oil	15 parts.
Alcohol	q. s. to make 100 parts.

It is a good stimulating liniment.

Allied Plants.—The genus *Brassica*, including *Sinapis*, has about eighty species, mostly of the temperate parts of Europe and Asia, and includes several of very

general use as food. The pungent qualities of mustard exist, to a slight degree, in many of them. *B. Rapa* Linn., rape-seed, a native of Southern Europe, extensively cultivated there for the fixed oil expressed from its seeds. *B. Napus* Linn., the origin of the numerous varieties of turnips, winter and summer. *B. oleracea* Linn., cabbage, also kohl-rabi, Brussels sprouts, cauliflower, etc. The order is a large one, of twelve hundred species, mostly of the north temperate zone. It includes numerous food plants, most of which are more or less pungent, but none really poisonous; also some favorite garden flowers.

Nasturtium officinale B. Br., Water-cress.

Alyssum maritimum Lam., the Sweet Alyssum of flower-gardens.

Lunaria annua Linn., "Honesty" in gardens.

Mathiola, Stocks or Gillyflowers, garden favorites.

Cochlearia officinalis Linn., Horseradish.

Camelina sativa Crantz, cultivated in Germany for its fixed oil.

Lepidium, var. sp., Peppergrass.

Raphanus sativus Linn., Radishes.

All the *Cruciferæ* have more or less pungency, due to their sulphuretted decomposition oils, of which that of Black Mustard and that of Horseradish are the principal types.

Allied Drugs.—As stomachics, see Cinnamon and other spices; also, more nearly, Onions, Leeks, Garlic, etc., besides the members of the mustard family. As emetics, Sulphates of Zinc and Copper; more remotely Apomorphine, Ipecac, Tartar Emetic, etc. As rubefacients and epispastics, Ginger, etc.; also heat, Turpentine, and more remotely, Cantharis, and many others.

W. P. Bolles.

MUSTARD, HEDGE (*Erysimum, Vélar Tortelle, Herbe aux Chantres*, Codex Med.), *Sysimbrium officinale* Scop.; Order, *Cruciferæ*. A common weed in this country, introduced from Europe, having a strong-tasting, bitterish herbage of about the same properties as radish tops; of no particular value. See Mustard. *W. P. Bolles.*

MYCOSIS, OR MYCOSIS FUNGOIDES, is a disease of the skin characterized by the appearance of soft, red, mammillated tumors, which may go on to the formation of fungous ulcers of unhealthy appearance. Anatomically the tumors show a development of lymphatic globules (small cell infiltration) and a reticulum analogous to that of lymphatic glands, whence the name "lymphadénie cutanée," proposed by some authors.

Symptomatology.—The symptoms characteristic of mycosis are variable at different periods of the disease. At first, bright-red erythematous patches on a level with the skin, or slightly raised above the general surface, appear at one or more points, accompanied by pruritus. These occasionally resemble the lesions of urticaria—in fact, urticarial patches have been observed in some cases. Later the lesions become covered with scales, or vesicles and papules, or may become raised, hard, and fissured, assuming somewhat the appearance of old, infiltrated eczema papulosum ("lichen"). At other times they may diminish and disappear like eczema, without leaving a trace. This peculiarity led Hardy to give his earlier cases the name of lichen hypertrophicus. While these erythematous or lichenoid lesions mark the earlier stage of the affection, sooner or later, after months, or perhaps years, it takes on the more especial features which give mycosis its peculiar and characteristic aspect. On, or alongside of, the lichenoid patches, vegetations and growths occur, at first wart-like, later profusely hypertrophic—frambœsioid. Once formed these lesions increase rapidly in size, and they may attain the dimensions of a cherry-stone, an almond, or a small orange. They are red, sometimes violaceous, vascular, somewhat firm, of uneven surface, so as sometimes to resemble tomatoes. The growths may be solitary or grouped and united at the base, but separated at the summit.

The surface of the hypertrophied tumors is at first dry, smooth, sometimes slightly scaly. The pruritus, a marked symptom of the early lesions, diminishes at this stage, and there may be even a slight diminution of sensibility, and any hairs which may grow from the surface are apt to fall out.

After continuing in this state for a considerable time the tumors may suddenly change in one of two quite diverse directions. Either they may, as some do, undergo rapid interstitial absorption, become retracted, shrivel up, and disappear, without leaving any trace, in ten to twenty days, or, on the other hand, they may become moist and crusted, or break down and suppurate profusely, with an ichorous discharge. Now and then the body of the tumor remains firm, while a crater-like cavity forms in its centre, and in rare cases the new-growth, followed by destructive metamorphosis, may go beyond the skin and penetrate the subjacent tissues to the very bone.

Simultaneously with the development of the skin lesions the lymphatic glands, especially those in the axillæ, groins, and cervical regions, increase in size, and become painful. While these glands may attain a considerable size, they rarely suppurate.

In the earlier stages of the disease patients usually preserve their health to a fair degree, but when the tumors multiply rapidly, and especially when they begin to suppurate, the general health fails; indigestion, diarrhœa, and marasmus supervene.

Mycosis may invade any and every portion of the integument, but the lesions are more frequently observed on the trunk, and on the proximal and inner portions of the limbs, than on the face and extremities.

Mycosis is an essentially chronic disease, taking usually years to run its course of erythematous and papular development, retrogression, relapse, hypertrophy, ulceration, etc. Exceptions occur, and the hypertrophic and rapidly ulcerating lesions may form the first stage in its development.

The disease usually terminates fatally, and even in those cases in which a return to health has been observed, the patients do not seem to have been kept under observation long enough to make it certain that a permanent cure had been obtained. Ordinarily the patient succumbs to some accidental complication, or to cachexia, or more frequently with the symptoms of leucocythæmia, or of lymphadenia.

Pathological Anatomy.—The pathological anatomy of mycosis is of importance, especially in relation to its diagnosis. Ranvier has shown that the disease consists essentially in the development and presence in various parts of the skin of lymphatic globules and adenoid tissue; in other words, of an organization essentially that of lymphatic tissue.

In addition to the principal lesion constituted by the presence of adenoid tissue, the epidermis is thickened, the mucous layer is also hypertrophied, and the interpapillary spaces are highly ramified and push into the derma. They contain a certain number of epidermic cellules, and those of the mucous layer are distended and occasionally ruptured, forming vacuoles as in vesiculation. The most important lesions, however, are those existing in the derma, where embryonal cells and a meshwork, of which the frame is more apparent as the superficial layers are receded from, and also lymphatic cellules are perceived. These changes are prolonged below the derma, and are quite marked in the subcutaneous cellular tissue. At the same time the cutaneous vessels are enlarged and gorged with blood, and large numbers of embryonal cells are contained in their walls. As the structure of these tumors resembles very closely that of sarcoma, it is not surprising that some observers, especially in Germany, have considered the affection essentially a sarcoma. Rindfleisch has proposed the name "lymphadenic myxoid sarcoma," while he, and also Auspitz, have detected a coccus in the tissues—the existence of which has, however, not been confirmed by other observers.

Diagnosis.—The diagnosis of mycosis at the outset is extremely difficult, if not impossible. Almost all those who have reported cases seen in the earliest stage have stated that the first diagnosis was *eczema*. In the case reported by the writer, under the title of "Ulcerative

Scrofuloderm," the eruption was at first taken for *lupus erythematosus*. When, however, the skin becomes markedly thickened, and when the tumors begin to appear, the diagnosis is more easy. Aside from the appearance of the tumors, which are red, irregular in shape, and framboesioid, the rapidity of their development, and the possibility of their complete spontaneous disappearance, are the special characteristics which serve to settle the diagnosis. The diseases with which fully developed mycosis is most apt to be confounded are molluscum, tubercular leprosy, the tubercular syphiloderm, and sarcoma of the skin.

From *M. epitheliale* the diagnosis is so easy that only a confusion of ideas with regard to the term molluscum could, one would think, allow of any error. (See Molluscum epitheliale and M. fibrosum.)

In *leprosy* there are certain changes in the skin somewhat resembling those of mycosis, as patches of erythema, anæsthetic areas, tubercles, ulcers, etc.; and both diseases are fatal. But in leprosy the patches are more brown, the anæsthesia is more complete and extensive, the cutaneous alterations are more permanent, and the ulcers are deeper and, when healed, leave cicatrices. Moreover, microscopic examination shows the bacillus of leprosy.

The cutaneous lesions of *syphilis* are quite different from those of mycosis in the earlier stages of the latter, and where the tumors of mycosis are fully developed their deep color, the pruritus which accompanies them, and their considerable size will prevent their being taken for syphilis. When ulceration follows, the borders of the ulcer are less sharply cut and indurated, and the suppuration is more abundant, more fluid, and more ichorous. Of course, a history of the appearance and course of the lesions will aid the diagnosis.

Sarcoma of the skin is the affection with which mycosis has been most frequently confounded, and many undoubted cases of mycosis may be found described under the designation of sarcoma or cancer of the skin. The difficulty of distinguishing between the affections has been enhanced by the fact that some writers consider mycosis to be a sarcoma. However, the facts that sarcomatous tumors are never preceded by eczemaform or "lichenoid" congestive eruptions, that the color of the skin is but little changed, that there is no itching, but that there is pain, and that there is no resorption, the tumors disappearing only by ulceration—all point to a marked clinical difference between the diseases. Moreover, the evolution of mycosis is more rapid, and neither sarcoma, epithelioma, nor carcinoma gives rise with such rapidity to voluminous, soft, brick-red tumors, like raspberries or tomatoes. In cases of difficult diagnosis the removal and microscopic examination of a tumor will show the presence of lymphatic globules, and the peculiar reticulum characteristic of mycosis.

Prognosis.—Mycosis is a grave affection, and of all the cases hitherto reported but one failed to terminate in death. But the course of the disease is prolonged, and long intervals of amelioration occur, so that, even where the diagnosis has been made with certainty, it is undesirable to express a positive opinion which will discourage the patient and bring despair to his family. A great increase in the number and size of the tumors, their ulceration, the appearance of general symptoms of cachexia, etc., point to an imminent fatal termination.

Etiology.—Nothing certain can, up to the present time, be stated regarding the circumstances which favor the occurrence of mycosis. It may occur at any age; Landouzy has observed it in a child seven months old. It is usually met with, however, between the ages of thirty and fifty. No hereditary influence has been observed in any case, and no immediate cause for the occurrence of the disease has been suggested.

Treatment.—No treatment as yet suggested has had much influence upon the course of the disease. However, it is generally agreed that a tonic and supporting regimen is desirable in the early stages. Later, arsenic, as in the treatment of sarcoma of the skin, may be employed. Hardy recommends arseniate of iron. Locally emollient baths, starch poultices, and inunctions, with the milder stimulants, such as oxide of zinc and calomel, may be employed.

When the tumors have attained some size and have commenced to ulcerate, iodoform, carbolic lotions, or stronger remedies, as ten to twenty per cent. pyrogallic acid ointment, or even chaulmoogra oil, as suggested by G. H. Fox, may be employed. All treatment, however, is merely palliative, and should rather be adapted to the general indications in each case than with the hope of any specific effect.

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Arthur Van Harlingen.

MYDRIATICS is the name of a class of drugs which dilate the pupil and paralyze the muscle of accommodation. Of these agents

Atropine has received the closest study. Its general chemical and physiological properties can be found under the heading Belladonna. The sulphate of atropine is commonly used for ophthalmic purposes on account of its solubility. A solution of 1 part in 80,000 of water dilates the pupil noticeably after the lapse of an hour, and leaves an effect for twenty-four hours. The solution commonly used in practice, 1 in 120, begins to widen the pupil in about fifteen minutes, and produces a maximum dilatation to the extent of eight millimetres in the course of some twenty to thirty minutes, which diminishes after three or four days, but does not disappear entirely short of from ten to fourteen days. The ciliary muscle is only weakened by solutions of about one-thirtieth to one-tenth per cent. in strength. Above this strength the state of paralysis is approached, and a one per cent. solution abolishes its action completely in the course of an hour. Its power returns about the second or third day, but it requires some eight days for complete restitution. These figures, like all physiological values, are only approximative. Any irritation of the eye, accidental or by disease, in its anterior part, diminishes both the extent and duration of the atropine effect. On the other hand, the action can be hastened, and finally prolonged indefinitely, by repeated instillation. The influence of atropine on the ciliary muscle causes the near point to recede from the eye, until the paralysis of the muscle abolishes all accommodative power.

Atropine will, therefore, reveal the true state of refraction of any eye. The enlargement of the pupil diminishes the sharpness of the retinal images, because the circles of diffusion due to any optic irregularity, or to any disproportion between the focal length of an eye and the position of its retina, increase with the size of the aperture through which the light enters. The blurring of sight is greatest in hypermetropia, and least in myopia, for evident optical reasons. The paralysis of the ciliary muscle misleads the judgment on attempting to use the accommodation, so that objects appear smaller than they really are. Atropine passes through the cornea into the anterior chamber. The aqueous humor of an atropinized eye can produce a slight mydriatic effect in another eye. The influence of the motor-oculi nerve upon the sphincter muscle of the iris is destroyed by this agent. But paralysis of this nerve, either experimental in animals, or by disease in man, gives the pupil but medium width, which is further increased by atropine. The agent must, therefore, exert its effect on another structure as well, presumably on the ganglionic cells found in the iris, which maintain a certain tonus of the sphincter. The muscular tissue itself is not paralyzed, because it still responds to electric stimulation, either through the living cornea or upon removal of the entire iris from the eye. It has been claimed that atropine stimulates the sympathetic or dilator nerve of the iris; but this view is not supported by any facts. Moreover, experimental stimu-

lation of the sympathetic nerves in animals will further increase the width of the atropinized pupil. When fully dilated by atropine, the pupil can be made to contract only by influences which cause congestion of the tissue of the iris, such as section of the fifth nerve and intense irritation of the front part of the eye.

Atropine, and presumably all mydriatics, raise the intra-ocular pressure slightly.

Homatropine is an artificial derivative from atropine. It is an oily liquid, the bromide of which is commonly used. Its action is identical with that of atropine, except as regards time. A single instillation of a two per cent. solution begins to widen the pupil after ten minutes, and paralyzes the accommodation completely in the course of an hour and a half, while its effects decline after three hours, and disappear in less than twenty-four hours. Homatropine produces generally a faint ciliary injection, without irritating otherwise.

Duboisine, in the form of sulphate or salicylate, is the most energetic of all mydriatics. It also seems to be the least irritating. Its action sets in quicker than that of atropine, and, when used in one per cent. solution, lasts about four days, the maximum being passed in twelve hours.

Hyoscyamine and its isomeric derivative, *hyocine*, are comparable in promptness of effect and transitory action to duboisine.

Daturine is probably chemically identical with atropine, and is certainly identical in its physiological effect.

Cocaine, which is more fully described in this work under its own name, dilates the pupil in the course of half an hour, but not as widely as any of the other mydriatics. Moreover, it does not paralyze the sphincter muscle of the iris, since there is still some reaction to light. It is not improbable that it acts by stimulating the sympathetic nerve-ends. This presumption is confirmed by the increase of dilatation obtained by the conjoined use of cocaine with any other mydriatic, as compared with the action of the latter alone. The cocaine mydriasis passes off in from two to four hours. This agent exerts little, if any, effect upon the ciliary muscle, and the accommodation cannot be paralyzed by its use.

Therapeutic Use of Mydriatics.—When it is desired to dilate a pupil for easier ophthalmoscopic examination, cocaine is the agent to be preferred, as it produces the least inconvenience to the patient, since it does not affect the ciliary muscle. If irritative disease of the eye prevents its action, homatropine deserves the preference on account of its transient effects. The inconvenience which atropine produces during several days should deter the surgeon from its indiscriminate use. The diagnostic paralysis of the accommodation for the measurement of the refraction in latent hypermetropia, astigmatism, or suspected ciliary spasm, can be accomplished sufficiently by means of homatropine in two per cent. solution, repeated at intervals of five or ten minutes until the effect is produced. The most important service to which mydriatics are put is to keep the pupil wide, and consequently free from adhesions, during the course of inflammatory disease of the iris. Atropine is the sovereign remedy on account of the intensity and duration of its action. It must be used in strong solution up to one per cent., and repeated at sufficiently short intervals every two or three hours, to maintain full width. If necessary, the surgeon may personally drop minute quantities of the drug in substance into the conjunctival sac, in order to force the dilatation of the adherent iris. The effect of atropine can be materially increased by the addition of cocaine. This combination gives a wider pupil, and has an even more soothing effect upon the pain of iritis than atropine alone. Where this combination is insufficient, the more energetic action of duboisine with cocaine may be tried, but this is usually without any greater effect. Adhesions of the iris remaining after inflammatory action has ceased may be torn in the course of time by the continued use of atropine, if they are not too firm. In all cases likely to be complicated by iritis, for instance perforating wounds of the cornea, rupture of the capsule of the lens, or severe contusion of the eyeball, it is safest to keep the pupil dilated from the start. Whether atropine is to be used in cataract operation depends upon the kind of operation (see article Cataract); but it should, at least, be used in most operations. Simple iridectomy does not require mydriasis when the tissue of the iris is not inflamed. Atropine is likewise unnecessary in cases of foreign bodies on the surface of the cornea, or of superficial ulceration of the cornea, unless a high degree of irritation is present, which renders the occurrence of iritis possible. Intense ciliary irritation is generally, but not always, allayed, and the pain it occasions diminished, by atropine. Mydriatics are likewise of advantage when absolute rest of the eyes is to be enforced, as in progressive myopia and in the asthenopia to which this gives rise. According to the gravity of the case, we can make use of the continuous action of atropine, or employ the milder homatropine for the sake of its effect during the night. In inflammation in the posterior part of the eyeball, nothing is ordinarily gained by the use of mydriatics. In intermittent convergent strabismus, due to hypermetropia, in children too young to wear spectacles, paralyzing the ciliary muscle by atropine or homatropine is sometimes, though rarely, sufficient to restore the normal condition of the recti muscles. Whenever mydriasis is to be kept up, it is more agreeable, and in inflammatory diseases more beneficial, to protect the eyes with tinted glasses or a shade.

Injurious Effects of Mydriatics.—Any mydriatic solution used carelessly by patients may trickle through the tear-duct in sufficient quantity to produce poisonous effects—dryness of the throat, scarlet rash on the skin, dizziness, and even delirium. Cases of poisoning from this cause have often been reported. Some patients present idiosyncrasies, and are affected by mere traces of one or the other drug. Especially is this the case with duboisine. It is well to change the mydriatic whenever such idiosyncrasy is observed. Atropine, when used for a long time, will produce in some susceptible persons an intense conjunctivitis, sometimes characterized by the appearance of follicles in the conjunctiva.

If further mydriasis is necessary in such a case, the agent must be exchanged for another one of this group. Occasionally this atropine-conjunctivitis has been produced by one of the first applications, though this is very rare. In order to avoid this unpleasantness the addition of morphine to the atropine solution has been advised. In the prodromic stage of glaucoma all mydriatics may do harm by bringing on an acute attack of this disease. Even cocaine has been reported as the cause of this accident. This experience is so decisive that mydriatics should be used only on unmistakable indications in elderly people, who are more disposed to glaucoma, and with special caution if the intra-ocular pressure is at all increased. The rise of tension produced by mydriatics is also injurious in cases of corneal ulcer, the floor of which shows any tendency to staphylomatous bulging; and it may be preferable to take the risk of adhesions of the iris rather than to endanger the future of the eye by permitting a staphyloma to form.

The details of the action and uses of mydriatics are found scattered throughout the periodical ophthalmic literature. A good *résumé* may be found in the older work by Donders, on "Anomalies of Accommodation and Refraction," and in the recent treatise by Landolt on the same subject. *H. Gradle.*

MYOMA. The myoma is a tumor which is chiefly composed of muscular tissue. The two varieties of muscular tissue which are found in the body—the non-striated or smooth muscular fibres, and the striated muscular fibres—may each enter into the composition of these tumors. The tumors which are composed of non-striated muscular fibres are known as *leiomyomas*, and those composed of striated muscular fibres as *rhabdomyomas*. Virchow has proposed the name of *myoma lævicellulare* for the non-striated tumor, and *myoma striocellulare* for the striated variety. In general, the term myoma, without any further distinction, is used for leiomyoma.

Of these two varieties, the tumor composed of smooth muscular fibres is by far the most frequent, and of the most clinical importance. The physiological type of the tissue, the smooth muscular fibre, is widely distributed over the body, and is best seen in the intestinal canal, and in the uterus. The smooth muscular fibres are long, fusiform cells, which are connected together by a small amount of cement substance. The nucleus of these fibres is a long rod-shaped body situated in the middle of the cell. The tumor is composed for the most part of such muscular fibre-cells which are arranged in bundles, separated from one another by a small amount of connective tissue which carries the blood-vessels. On section of the tumor these bundles will be cut at various angles, and when the nuclei are brightly stained, the section often appears peculiar. When a bundle of fibres is cut exactly across, the section of the muscular fibres, with the brightly stained nuclei in the centre, may be mistaken for round cells with a central nucleus, or, still more readily, for a section of a nerve. The nuclei may be mistaken for connective-tissue nuclei and the tumor for a fibroma. In the myoma the nuclei are longer, narrower, and more refractive than connective-tissue nuclei, and in the fibroma the arrangement of the fibres in bands is never

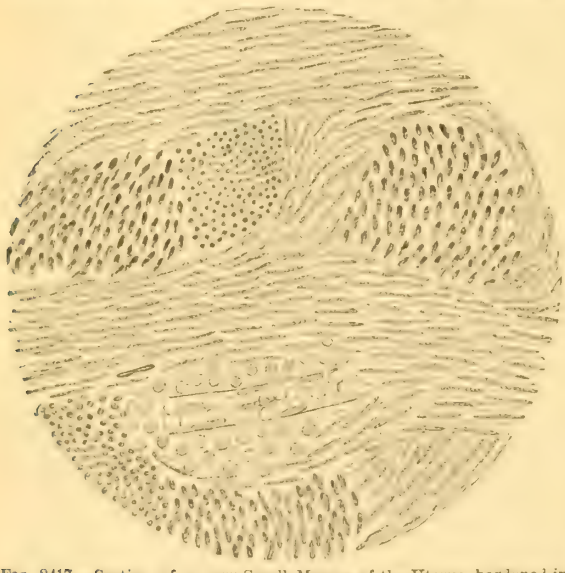

FIG. 2417.—Section of a very Small Myoma of the Uterus, hardened in Müller's Fluid and stained with Hæmatoxylin. Bands of muscular fibres are seen cut in various directions. (× 175.)

so characteristic as in the myoma. In cross-section of the fibres the muscle substance around the nucleus is seen to be denser, more homogeneous, and more refractive than the protoplasm of other cells. When fresh unstained sections are examined the tumor may be mistaken for a sarcoma, in which the cells are often arranged in bundles in the same way, but a careful study of the nuclei will reveal its true character. The separate cells which compose the tumor may be isolated by macerating small portions in a twenty per cent. nitric acid solution, or in a thirty per cent. solution of caustic potash. This dissolves the cement substance between the muscular fibres, and they can then be readily teased apart. There is often a considerable difference in size between the tumor-cells and the cells of the analogous physiological tissue. The cells may be very much larger or very much smaller than these. Sometimes cells as large as the muscle-cells in the rapidly growing pregnant uterus are found. There is always with the muscular tissue a variable amount of connective tissue, which is principally found between the larger muscle-bundles. From this smaller septa are given off which run between the smaller bundles of cells. In this connective tissue run the blood-vessels. In some cases the connective tissue is so abundant that it forms a considerable part of the tumor, and in others there is scarcely any present, except around the larger vessels. The amount seems to vary with the age of the growth, being always less in small tumors of recent formation. When there is much connective tissue present it is generally firm and fibrous, but in some places it may have more the character of loose areolar tissue, and contain numerous lymphoid cells. In some of the very large myomas of the uterus the development of connective tissue is so great that the tumor appears to be principally composed of this, and it is only after considerable search that the muscular tissue is found. In almost every tumor some places will be found where neither muscular tissue nor connective tissue can be made out. There are larger or smaller areas of firm, highly refractive, homogeneous tissue, in which a few rod-shaped nuclei are scattered. Such areas are most abundant in the larger tumors, and represent a coagulation necrosis of the tissue. It is probable that the place of this is afterward taken by the connective tissue, and a coagulation necrosis of the muscular elements very generally precedes the formation of connective tissue. As a rule, the myomas have a very poor vascular supply, but cases are sometimes seen in which the blood-supply is so abundant that the tumor almost resembles a cavernous tissue. This variety of tumor will be considered more fully in speaking of myoma of the uterus.

Macroscopically, the myoma resembles most the hard fibroma or one of the sarcomas. It is always sharply circumscribed, and generally surrounded by a firm capsule of connective tissue. On section of the tumor it can always be easily separated from the tissue surrounding it. The cut surface has a whitish or yellowish color and glistens. It is not homogeneous, but marked by fissures and lines which represent the spaces between the muscular bundles, and which often have a concentric or spiral direction. Whiter and darker patches are sometimes seen on the surface, which generally depend on degenerative processes in the tumor.

The tumor always develops from non-striated muscular tissue. Unlike the rhabdomyoma, it never develops in any locality where this tissue is not found; it is never heterologous. The exact mode of development is not known. Förster supposes that it develops from the muscular fibres, but others, following Kölliker, believe that it arises from the connective tissue, in the same way that Kölliker supposes the new production of muscular fibres in the pregnant uterus takes place.

The growth of the tumor is slow, but it may continue many years. The rapidity of growth depends on its vascularity and the general conditions favoring its nutrition. The distinction has been made between the tumors having much connective tissue and the purer forms. The former have been called fibro-myomata. This distinction has nothing to recommend it, for there is every transition form between the two, and, in addition, the development of connective tissue depends largely on the age of the growth.

The most frequent place of the formation of the tumor is the uterus. Every variety of the tumor is found, and it can best be studied here. The chief mass of these tumors is composed of muscular fibres, which are generally much larger than those of the unimpregnated uterus. The increase in size affects principally the width of the cell and the nucleus. Cells are often seen which are wider than the diameter of a red blood-corpuscle. The muscular fibres are arranged in bundles, which join at acute angles to form larger bundles, which are surrounded by wide capillary vessels. The walls of these vessels consist of a single layer of endothelial cells with large nuclei, and they are supported by a thin layer of connective tissue. Both between the muscle-bundles, and between these and the connective tissue of the vessels, are small spaces which contain white corpuscles, and are surrounded by a fine tissue in which here and there nuclei are enclosed. In this way a cavernous structure is formed, which is not present in the normal uterus. Klebs supposed that these spaces represent lymphatic cavities, in which the whole tissue, muscular fibres and blood-vessels, are suspended by the small bands of connective

tissue. Larger blood-vessels, with thick walls and a wide adventitia, are but seldom found, and then in the broad partitions between the larger bundles of muscular fibres.

The tumors may increase in size by the joining together of neighboring growths, but this mode of increase is rare. Generally it appears that the same process of new formation, in consequence of which the smallest and most simple myoma was formed, repeats itself in the substance of this. Every single vessel, with the muscular and connective tissue belonging to it, proliferates again, and forms a second generation of nodules, which are situated in the original tumor. These different centres of growth can usually be easily made out, and sometimes the arrangement is such that the tumor appears to be composed of triangular masses, the apices of which point to the centre and the base is along the periphery of the tumors. In other cases, the formation of secondary nodules only takes place in certain parts of the tumor, and in this way very irregular, uneven masses arise. This peculiar process of growth leads to displacement of the tumor, which originally is enclosed in the walls of the uterus. If the growth takes place most rapidly in the

Fig. 2418.—Uterus containing numerous Myomata, some Intra-mural, others Submucous. The uterus was hypertrophied in all its parts. (Specimen drawn one-half natural size.)

part of the tumor nearest the mucous or the serous membrane, that part escapes from the muscular tissue, and projects into the uterine cavity or on the surface of the organ, and finally the whole tumor becomes separated from the uterine walls. In this way the submucous and subserous varieties of the tumors arise, which are either connected with the uterus by a narrow pedicle or have a wider attachment. This attachment often contains dilated venous vessels in the loose connective tissue. When the connective tissue is much developed the tumor becomes denser and harder than it was, and on section the lines and fissures are not so evident. The lymph-spaces and blood-vessels become narrower and partly obliterated. The smooth muscular fibres remain preserved, but the single fibre-cells can no longer be recognized, and in place of them small, long, rod-shaped nuclei are found imbedded in a substance which appears more or less fibrillar. In general, it may be said that the better the development of the blood-vessels, the less connective tissue will be found. As said, its appearance seems to follow degenerative processes in the muscular fibres. The best conditions of nutrition are found in the small tumors of the uterus, which sometimes are composed entirely of muscular fibres and blood-vessels. Such tumors have the grayish red, dull appearance which the uterus shows on section, and microscopically cannot be distinguished from the uterine tissue. The small lymph-spaces which were spoken of may become widened to form large cysts filled with clear fluid. Often these do not seem to have a special lining membrane. Small processes of connective tissue sometimes grow from the walls of these cysts, which penetrate between the adjoining bands of muscular tissue, and in this way a series of smaller cysts may arise. These cysto-myomata of the uterus may attain a large size, especially when, as often happens, heterologous formations of a myxomatous or sarcomatous character arise in them. Single cysts of large size, entirely surrounded by muscular tissue, are sometimes found. Their contents are fluid, generally more or less colored with blood-pigment from numerous hæmorrhages which have taken place into them. The contents of all these cysts will usually coagulate spontaneously. The walls often contain a layer of fibrin of variable thickness, and the cyst may be traversed by bundles of muscular tissue. Dilated blood-vessels are often found in the neighborhood of the tumor, and in the extra-mural forms run in the loose connective tissue of the attachment. These are the most frequent source of the hæmorrhages which so often accompany this form of tumor, they being often torn across by the traction of the tumor. The dilatation of these vessels is nothing but a passive process, but in some cases there is a very abundant formation of vessels in the tumor itself. Virchow distinguishes this variety under the name telangiectatic or cavernous myoma. The writer has had occasion to examine a marked example of such a tumor. The patient, a widow woman of sixty, had suffered for ten years from repeated uterine hæmorrhages. She was seized with violent cramp-like pains in the uterus and had a more than usually severe hæmorrhage. Her physician was sent for, and on his arrival found a large mass of tissue inside the vagina. The mass was about the size of an adult fist and looked very much like placental tissue. On microscopic examination it was found to be a myoma in which there had been an enormous development of blood-vessels. The large vessels were composed of a single layer of cells, and in places where they were most developed the tissue had the appearance of the corpora cavernosa. There was little or no development of connective tissue, and the vessels were immediately in contact with the muscular bundles. It is in such tumors that marked variations in size are seen, the tumor appearing sometimes double its usual size. It is probable that this variability in size may be due both to changes in the amount of blood in the dilated vessels, and to different degrees of contraction of the muscular cells.

There may be mixed forms of myomata. The most frequent combinations are with myxomatous and sarcomatous tissue. The latter is much less frequent than the former. Such tissue develops around the vessels in the septa between the bundles of muscles. The myxomatous tissue in the tumor can be recognized as patches of grayish, gelatinous material, and the sarcomatous portions are whiter and less refractive than other parts. Combinations with other forms of tumors do not take place. In the uterus, carcinoma may co-exist with myoma, and the carcinoma may erode and grow into the myoma in the same way that it grows into the muscular tissue of the uterus itself.

Of the degenerative processes the most frequent, after the coagulation necrosis, is calcification, which may affect the whole tumor or only portions of it. When the calcification is complete the whole tumor may be changed into a hard, stony substance, in which no tissue or blood-vessels can be made out. Generally the process is not so complete as this, and a network of calcified tissue traverses the tumor, in the meshes of which small bands of muscular tissue and vessels are seen. In some cases a true formation of osseous tissue has been made out in the tumor.

The myomata of the prostate come next in importance to those of the uterus, and are most frequently found in advanced age. Some of these enlargements of the pros-

tate depend on an actual hypertrophy, in which all parts of the gland participate. In others the enlargement is principally due to hyperplasia of the glandular elements, and this form passes most readily into adenoma. In the third class Virchow has shown that the enlargement is principally due to a hyperplasia of the smooth muscular fibres, which make up a large part of the gland.

This new formation is sometimes diffuse, but more often is in the form of distinct nodules. The favorite seat for their formation is on the posterior upper end of the gland, and this distinct tumor formation here is what is generally spoken of as hypertrophy of the third lobe of the prostate. The lateral halves of the gland are the next most frequent seat of this formation. It is rather rare that the anterior part of the gland is affected, although Thompson has described a tumor here as large as a walnut.

The myomata of the digestive tract are, next in order, most frequent. Their microscopic characters do not present any differences from those of the uterine myomata. Cyst formation and degenerative processes are not commonly found. They are found in the œsophagus, gen-

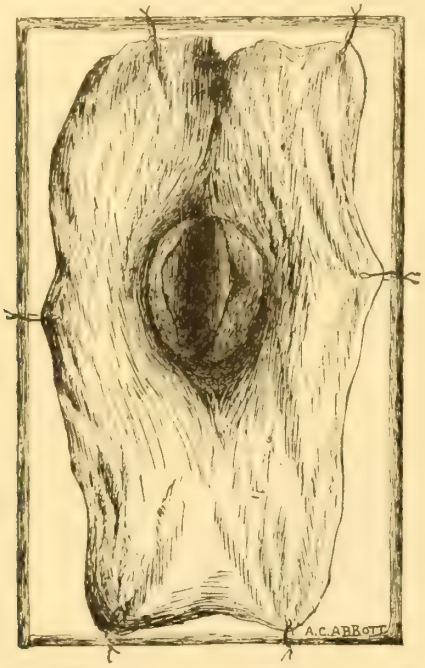

Fig. 2419. Myoma of Œsophagus. (Natural size.)

erally near the cardiac end, in the stomach, and in the intestine. They are comparatively rare in all these localities, they seldom attain a large size, and usually do not give rise to symptoms. Fig. 2419 shows such a tumor, which was seated in the upper third of the œsophagus of a woman aged thirty. These tumors develop from the muscular coats of the canal, soon project into the lumen, covered only by the mucous membrane, and may become pedunculated.

Although the myoma is not in itself a dangerous tumor, still it may cause dangerous complications. In the uterus myomata are a frequent cause of hæmorrhage when seated beneath the mucous membrane. When on the outside of the organ, they may exert pressure on the rectum or bladder, or by their weight produce flexures or versions of the uterus. They may form adhesions to other organs, and in this way cause intestinal strangulation. When such adhesions are formed, new blood-vessels grow into the tumor from the place of adhesion, and in this way it may receive a further stimulus to growth. The subserous myomas often attain an enormous size, and from this alone they prove dangerous, especially since operative procedures for their removal are not attended with success.

Nothing at all is known as to the cause of the myomata. It cannot be shown that irritation exerts any influence. They are found most frequently after middle life.

Myomata of the uterus are far more frequent in blacks than in whites. The percentage of negro women over the age of fifty who have not one or several uterine myomata is small. On the other hand, the analogous tumors of the prostate are much more frequent in white men than in black.

The second form of the myoma, the *rhabdomyoma*, into whose structure striated muscular fibres enter, must be considered as one of the rarest of tumors. The first of these tumors was described by Rokitansky, and since then not more than thirty or forty cases have been reported. Recklinghausen found in the hearts of newly-born children, in a few instances, small tumor masses which contained striated muscular fibres. Generally the tumors are not pure forms, but mixed with sarcomas. The muscular fibres are, as a rule, not straight and arranged in masses, but separated from one another, and irregularly distributed in the tumor. The character of the fibres varies. Generally they are spindle-shaped, and may not be longer or wider than the smooth fibres.

The most frequent place of formation of these tumors is in the genito-urinary system, in the kidneys or testicles. They are found almost exclusively in children, and may reach a very large size; as in the case described by Marchand, in which such a tumor of the left kidney extended from the diaphragm to the pelvis, and weighed 2.770 Gm. They are always heterologous, never seeming to originate from muscular tissue. Most probably the explanation given by Cohnheim of their origin, which refers them to unused embryonic material, is the correct one. Their presence in such parts where complications in the embryonic formations take place, and where there is a mingling of the germinal layers, speaks in favor of this. *W. T. Councilman.*

MYOPIA. Definition.—Myopia, near-sightedness, or short-sightedness, is that state of refraction of the eye in which objects can only be seen distinctly if within a certain short distance from the eye, but appear blurred when they are situated beyond that distance. The point beyond which sight is blurred is the far point of the eye (Punctum remotum, P. R.). Practically, M. is recognized whenever the far point lies nearer than two metres (about seventy-five inches) to the eye, while in extreme near-sightedness it may be no further than four centimetres from the eye. Between the far point and the eye distinct sight reaches as near to the eye as the power of accommodation allows the organ to adjust itself, which range varies with age. Distinct sight depends on the formation of sharp images, and these are formed on the retina of any eye only when this membrane is in the plane of the point of reunion of the rays coming from the corresponding object. The nearer the object is situated to the eye the farther behind the cornea is the plane in which a sharp image is formed of it. It is evident, therefore, that in the myopic eye the position of the retina corresponds to the place of reunion of the rays coming from the far point of that eye; while the focus of rays coming from an infinite distance, in other words, of parallel rays, is situated in front of the retina. The myopic eye has thus too high a refractive power relatively to its length, that is to say, to the distance between retina and cornea.

The relatively excessive refraction of the myopic eye can be corrected by means of concave glasses, which diminish the refraction to the required extent, so that the focus of the new system, viz., the eye plus the concave glass, coincides with the position of the retina. The myopic refraction is exactly corrected by holding closely in front of the eye a concave glass, the (negative) focal length of which is equal to the distance of the far point from the eye. We may designate the degree of myopia by the distance of the far point from the eye, or, conversely, by the dioptric strength of the glass required to correct the short-sightedness. Thus we speak of a myopia of $\frac{1}{36}$, $\frac{1}{15}$, or $\frac{1}{4}$, meaning that the far point is 36, or 15, or 4 inches from the eye. If we use the metric notation,

we designate the myopia by the number of dioptrics of refraction by which the myopic eye exceeds the emmetropic eye. Thus a myopia of 1, 4, or 10 dioptrics has its far point at a distance of 100, 25, or 10 centimetres (compare art. Accommodation and Refraction, ¶ 20), and is corrected by a concave lens of the strength of 1, 4, or 10 dioptrics.*

The disproportion between the focal length of the myopic eye and the position of its retina may be due to excessive refractive power of the eye—that is to say, too great a convexity of the refracting surfaces—combined with an average length of eyeball; or it may be due to an average refractive power in an eye of greater than normal length—which latter is the more common cause. M. can also be simulated by a spasm of the ciliary muscle and accommodative apparatus. Although ciliary spasm is not identical with M., it will be most convenient to discuss it in this article.

M., as thus defined, is an optic condition depending on structural peculiarities. The latter may be a simple anomaly of growth, or they may amount to a progressive morbid change. We can hence distinguish between simple and malignant M.

Symptomatology.—The myope complains of indistinct sight beyond his far point. Every objective point appears to him as a circle of diffusion, and hence all contours are blurred. The amount of blurring of objects at any distance beyond the far point depends, of course, upon the degree of M., as well as on the actual distance of objects beyond the limit of distinct sight. But the indistinctness, like the circles of diffusion which give rise

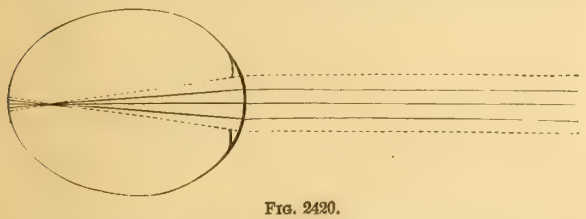

Fig. 2420.

to it, increases also with the size of the pupil, as illustrated by Fig. 2420. The acuity of sight varies, furthermore, with the practice of the individual, of mentally ignoring the circles of diffusion according to his habit of wearing glasses or not, and according to the training which his eye has received in the recognition of distant objects. On examining numerous myopes we may find a visual acuity of about

$^{20}/_{20}$ to $^{20}/_{40}$ in M. of	0.5 D.
$^{20}/_{40}$ to $^{20}/_{100}$ "	1 to 2 D.
$^{20}/_{60}$ to $^{15}/_{200}$ "	2 to 4 D.
$^{20}/_{100}$ to $^{5}/_{200}$ "	4 to 6 D.
$^{15}/_{200}$ to $^{3}/_{200}$ "	6 to 8 D.
$^{6}/_{200}$ to $^{1}/_{200}$ "	8 to 10 D.

On testing the sight at the far point of the myopic eye, or at any greater distance, after correction by means of concave glasses, it may be found normal in the lower and even medium degrees of M. More often, however, it is found reduced, and in M. of over 6 D. this is almost invariably the case. In the examinations of recruits Seggel[1] found the average sight of fifteen thousand emmetropic eyes to be 1.1, as tested with Snellen's types, while seventy-four myopic eyes, of 0.5 to 0.75 D., gave only 0.92 V. In one hundred and eighty-six eyes of M. 3 to 3.75 D., the V. was 0.75; in sixty-eight eyes of 8 to 10 D. the V. was 0.53, and in twelve eyes of 14 to 20 D. the V. was only 0.13. Of all the myopic eyes, only about twenty-five per cent. had normal sight. This reduction of sight cannot be accounted for on optic grounds. It depends, probably, on some structural or nutritive change in the retina, caused by the lesions of myopia.

In bright light the myope sees better on account of the narrowing of the pupil. Myopia, however, is characterized by a pupil of more than average width. This is usually accounted for by the comparative relaxation of the accommodative apparatus, which in uncorrected M. is less called upon than in emmetropia. Many myopes diminish the size of the aperture through which light enters by partly closing their lids—whence, indeed, the name myopia (μυειν, to wink). In some few instances myopes can also gain another advantage by partly closing their lids. It has been shown by Weiss,[2] by measurement with the ophthalmometer, that some persons can thus flatten the cornea and thereby correct their myopic refraction. This habit of winking gives myopes of a high grade a rather characteristic appearance. Higher degrees of M. reveal themselves, moreover, very often by the prominence of the eyeballs, due to their excessive length in an orbit of ordinary size. As further characteristics of M. may be mentioned an habitual embarrassment on looking at distant objects without glasses, on account of the inability to recognize details.

The power of accommodation is about the same in M. as in the ideal emmetropic eye, in individuals of the same age. If the accommodation is not exercised much on account of not wearing glasses, and hence reading or working practically near the far point, the range is apt to be somewhat reduced. The absolute distance between the far point and the near point is, of course, less in M. than in E., and diminishes the higher the degree of M.; for we measure the power not by linear distance, but by the refractive strength of the glass equivalent to the accommodation. For instance, in M. $= \frac{1}{8}$, with an accommodative power of $\frac{1}{6}$, the near point will be at four and a half inches, for

$$\frac{1}{PR} + \frac{1}{A} = \frac{1}{PP}, \text{ or}$$

$$\frac{1}{18} + \frac{1}{6} = \frac{4}{18} = \frac{1}{4\frac{1}{2}};$$

while a myope of 6 D., with accommodative power equal to 4 D., can see distinctly at ten centimetres distance from the eye; for

6 D. + 4 D. = 10 D. = $\frac{100}{10}$ centimetres = 10 centimetres.

(Comp. art. Accommodation, ¶ 41.)

The size of the retinal images is greater in M. than in E., because the size of the image (b) is to the size of the object (B.), as the distance of the image from the (second) nodal point (g_{11}) is to the distance of the object from the (first) nodal point (g_1); or,

$$b : B. = g_{11} : g_1;$$

and in M. of any extent g_{11} is greater than in E., on account of the increased length of the eyeball. However, the enlargement of the images does not amount to more than about one and a half time their size in E., even in the highest degrees of M.; while in low grades it is very slight, and in M. due to relatively too great a convexity of the refracting surfaces it does not exist.

The slight advantage of amplification of retinal images in M. is more than compensated by their indistinctness, if the objects are beyond the far point. But when the objects lie within the range of the accommodation the myopic eye is indeed at a slight advantage. This benefit is too slight, however, to justify the popular notion that the myopic eye is a strong eye. This false belief is perhaps also based on the idea, that in M. glasses are not needed for close work when the person advances beyond the forty-fifth year of life, at which age spectacles are ordinarily required. But this slight gain is more than paid for by the necessity of wearing glasses all the life long in order to see distinctly in the distance, while in M. greater than about 3 D. it is not advisable to work without concave glasses at any age.

Apart from the indistinctness of sight beyond the far point, all other functions of the myopic eye can be perfect as long as no complicating disease of the eye is present. The extent of the visual field, the color-sense both of the centre and of the periphery of the retina, and the power of distinction of differences in brightness, do not vary in M. from the average. In the higher degrees of M. the acuity of sight is, however, very often below the normal—almost always so in M. of over 7 D., and not in-

* For the sake of brevity the following abbreviations will be used hereafter, viz., M. = Myopia; E. = Emmetropia; H. = Hypermetropia; D. = Dioptrics; V. = Visual acuity.

frequently in M. greater than 3 D., even after full correction with concave glasses and allowance for any slight astigmatism that may be present. Such short sighted eyes with reduced V. are not necessarily in any state of progressive disease. The cause of this diminished power of distinction is not understood. In the uncomplicated cases, the microscopic autopsy has not shown any change in the retina. While concave glasses diminish the size of the retinal images, they do not do so to a sufficient extent to account for the reduced sight. It can be observed in some instances that the visual acuity, as tested after correction with glasses, rises considerably during the course of a treatment consisting mainly in rest of the eyes. When complications are present, which occur frequently in the higher grades of M., sight may, of course, be very much impaired, and in many unfortunate instances of extreme M., the sensitiveness of the retina has suffered to such an extent that the optic correction by means of glasses scarcely improves the sharpness of vision.

A frequent occurrence in M. is the insufficiency of the internal recti muscles. This can be demonstrated and measured in the most practical way, by the method of Landolt. A small lamp or candle is surrounded by a blackened chimney, a vertical slit in which serves as an object of fixation. While the patient observes attentively this source of light, the candle is approached to the eye until the internal recti muscles are no longer able to maintain the necessary convergence of the two eyes, whereupon the slit appears in double images. This distance is then measured in inches or centimetres. A convenient manner of expressing the power of convergence is by means of the "metric angle" notation, devised by Nagel, which correlates the power of convergence to the range of accommodation. The standard by which we measure the power of accommodation is the metric lens or D., a lens of one hundred centimetres focal length. Similarly, Nagel chose, as a unit for the measurement of the power of convergence, the angular rotation of the eyes necessary to direct them toward a point one metre distant from the forehead, and called this degree of angular deviation of the eyes a metric angle (M. A.). In order to direct both eyes toward a point only fifty centimetres off, twice this amount of convergence is required, equal to two M. A., while a convergence of twenty M. A., which is about the limit in health, enables the eyes to be directed toward an object at a distance of five centimetres from the forehead. The actual degree of rotation through which each eye must pass in order to converge with its mate for distinct sight at any given distance, depends, of course, upon the distance between the two eyeballs. Practically, however, we do not find that the inter-ocular distance influences the absolute power of convergence to any noticeable extent. Unless there are mechanical hindrances to the movement of the eyes, the number of M. A. of convergence which the individual can command is determined by the relative strength of the internal recti muscles, as compared with the elastic resistance to traction of the external recti muscles. Clinical observation shows that in M. the balance of power is more in favor of the external recti than in H. or E. The majority of myopes cannot maintain the convergence for a point two or even four inches from the eye, and an object brought thus near, for instance the illuminated slit in Landolt's method, appears in double images. In the higher grades of M., the power of convergence amounts often to less than eight M. A. The significance of this insufficiency of the internal recti muscles is, that the convergence for the ordinary reading distance cannot be maintained without fatigue. We cannot exert any muscle to the maximum of its strength without its speedy exhaustion. Landolt has found that the convergence can only be maintained with comfort, for any length of time, if about one-third of the possible number of M. A. is made use of.*

Thus, a myope with a power of convergence of 12 M. A. can only employ four of them to advantage, being thus unable to read at a shorter distance than 25 centimetres for any length of time; or if he has not the 12 M. A. at his disposal and persists in holding his book 25 centimetres off, his strength will soon give out. The result is asthenopia, the inability to use the eyes without discomfort. In cases of very marked insufficiency of the internal recti muscles, the condition often remedies itself after a while, as far as mere comfort is concerned, by the loss of binocular vision. In such cases, in which convergence can be maintained only by extreme effort, the internal recti muscles relax in the course of time to a sufficient extent to cause permanent divergent squint, which is not an uncommon occurrence in M.

It has been much discussed whether the M. is the cause of the insufficiency of the internal recti muscles in the first place, or, on the other hand, how important a factor the muscular anomaly constitutes in the origin of short-sightedness, but without an absolute solution of the question being arrived at. It is quite evident that any considerable lengthening of the eyeball, such as exists in the higher degrees of M., must limit the converging power, by reason of the greater stretching to which the external rectus muscle is subjected when the eye is rotated inwardly. For in such high grades of M. the eyeball is not an approximate sphere, but is elongated at its posterior pole, which prominence must push the external rectus muscle outward, and thereby stretch it when the eyes converge.

Much less reliable than the method of Landolt, for the detection of insufficiency of the internal recti muscles, is the plan of observing the position which the one eye assumes when excluded from binocular sight by covering it. A moderate degree of divergence of either eye under cover, while the other looks at an object, is quite common, even when by Landolt's methods the power of convergence is found normal. Of course, very decided divergence resulting upon the exclusion of binocular sight, indicates insufficiency of the internal recti muscles, but gives no measure of its extent.

Besides the muscular asthenopia due to insufficiency of the internal recti muscles, the myopic eye suffers occasionally from a form of asthenopia peculiar to short-sightedness. Before ascribing the difficulty of using the eyes to the M. as such, in any given case, we must exclude all other causes of asthenopia. We can distinguish between the following varieties of asthenopic complaints:

I. Asthenopia of conjunctival origin, in which a chronic inflammatory state of the conjunctiva (generally marked by the presence of minute follicles) is the cause.

II. Asthenopia due to disease of the lachrymal sac, or duct, in which the overflow of tears brought on by activity of the eyes irritates them after a while, so as to interfere with their comfortable use.

III. Asthenopia of nasal origin, hitherto but little recognized. In this form, quite frequent in the writer's experience, the interference with the use of the eyes shows itself in about the same way as in the varieties previously mentioned. On using the eyes—for reading or for other close work—they become irritable and often slightly reddened, smart and itch, until actual pain ends the attempt to use them. In the nasal form the interference with the work begins, as a rule, pretty soon after use of the eyes; and, indeed, patients with this trouble are generally not entirely free from annoyance, even when the eyes are at rest. The discomfort in this form is not fully relieved by a night's rest, and if anything, aggravated by the recumbent position during sleep. The nasal change causing this asthenopia may be very slight —a low grade of catarrhal inflammation, or merely enlargement of the plexus of blood-vessels. In doubtful cases the diagnosis depends on the result of the nasal

* My experience in the higher degrees of M. leads me to differ slightly from Landolt, in expecting muscular asthenopia when the number of available M. A. is less than three times the actual number of M. A. required for work. For in such extreme cases the internal rotation is hindered mechanically by the great length of the eyeball, although the balance of power may be in favor of the internal recti muscles for moderate degrees of convergence. I have seen myopes of six to seven D. with only eight M. A. of convergence at their disposal, work comfortably at about twenty centimetres distance. It must be remembered that in the case of such elongated eyeballs, the work imposed upon the internal recti muscles increases in almost a geometric ratio with every additional M. A. of convergence.

treatment by astringents, especially the use of nitrate of silver, or the galvano-cautery. It is not rare to find these three different forms of asthenopia combined.

IV. Muscular Asthenopia, as described in the previous paragraph, and due to insufficiency of the internal recti muscles. In this and the accommodative variety of asthenopia, to be presently mentioned, the discomfort—being a muscular fatigue—amounts to an actual ache, besides the other signs of irritability of the eyes previously referred to. Moreover, the exhaustion of the muscles can give rise after a while to blurring of the objects viewed.

V. Accommodative Asthenopia. This form of inability to use the eyes persistently occurs in M., whenever the accommodative apparatus cannot be adjusted for the reading or working distance without fatigue. The range of accommodation sinks in M., with age, at the same rate as in the emmetropic eye. The myope is not exempt from presbyopia, and in M. of less than about two D. he must make use of convex glasses for work as he grows old. But a strain of the accommodation must occur even in M. of any degree, if the individual wears his fully correcting concave glasses for work at a time when his accommodative power has become enfeebled by age or any exhausting disease. Another common cause of asthenopia is the combination of M. with astigmatism. Further reference to this subject will be found in the paragraph on Treatment.

VI. Neurasthenic Asthenopia shows itself as an inability to use the eyes for work, for any length of time, in the various forms of nervous exhaustion. In such cases no further cause can be assigned beyond the speedy exhaustibility of the muscles in general, and of the nervous system. This complaint can of course occur in M., as well as in any other type of eyes.

VII. Myopic Asthenopia proper can be recognized only after excluding the other forms of complaint. These patients can generally use their eyes for perhaps half an hour or more, without suffering from any feeling of strain and discomfort. They complain often of sensitiveness to light, and are annoyed by the appearance of dark specks floating in front of the eyes. Myopic asthenopia is most likely to occur in eyes the M. of which is increasing at a more or less rapid rate, be it a low or high grade of short-sightedness. Generally the acuity of sight is found reduced even on full correction, and in these very cases the visual power can often be improved by rest and treatment. We do not fully understand the cause of the asthenopia dependent upon M., and must refer it to nutritive disturbances in the eye produced by the elongation of the eyeball.

Myopia Complicated with Astigmatism.—The joint occurrence of M. and astigmatism is much more common than is usually acknowledged in ophthalmic literature. Among the many examinations of the refraction of schoolchildren and other classes of persons, published by numerous authors, astigmatism is scarcely mentioned, yet the writer's records show this complication to be present in about one-half of his cases of M., to the extent of at least 0.5 D., and mostly more than 1 D. These are records, however, of private practice, which would include relatively more of the refractive complaints that could not be corrected satisfactorily by the purchase of glasses without expert examination. Any proportion may exist between the degree of M. on the one hand, and astigmatism on the other. The occurrence of this complication may subject the myope to asthenopic complaints, if the inequality in the refraction of the two meridians is at all considerable, unless the visual power is reduced ; for the less the retina is sensitive to circles of diffusion, the less disturbance is produced by them, and the less is the tendency to strain of the ciliary muscle in the attempt to correct the indistinct sight. The astigmatism increases the apparent M., at least as judged by the visual acuity when not corrected by lenses, and, indeed, on trial a concave glass may be accepted which corresponds, not to the real M., but approximately to the refraction in the most myopic meridian. There is often, in such cases, irregular contraction of the ciliary muscle on attempting to see accurately, which equalizes in part or entirely the refraction in the different meridians. On the other hand, M., apparently increased by astigmatism, is less likely to prove progressive than would be a simple M. of the same degree. The writer's experience, based on the continued observation of many such complicated cases, favors the view that the greater the amount of astigmatism, as compared with the degree of M. present, the more likely is the optic effect to be the result of a stationary anomaly of the shape of the eyeball, without tendency to further increase or secondary complications. Astigmatic eyes, however, have often a reduced sight even on full correction, not as the result of morbid changes, as in M., but as a congenital defect.

Ciliary Spasm.—Whenever the ciliary muscle contracts and the accommodative apparatus is put into play, the refractive power of the eye is increased, so that the accommodating emmetropic eye is optically comparable to a myopic eye. Any actual spasm of the ciliary muscle can therefore simulate myopia. But it is only justifiable to speak of a ciliary spasm when the contraction of that muscle does not cease on relaxing all efforts at distinct sight, and when it requires the paralysis of the ciliary muscle by means of atropine (or one of its substitutes) in order to remove the apparently myopic refraction.

Different from such tonic spasm is the activity of accommodation maintained in the interest of distinct sight during all attempts at recognition of objects. A typical instance of this is the complete or partial correction of hypermetropia by accommodative activity, which, however, relaxes when the individual gazes vacantly without looking sharply at any object. By means of the ophthalmoscope the actual refraction can be accurately measured in such instances, as long as the patient makes no effort to recognize anything sharply. But as soon as he fixes his attention upon small objects at a distance, the ophthalmoscope shows at once an apparent increase of refraction. For this very reason a correct estimation of the refractive deficiency in H. cannot be made with glasses and reading tests, because the attempt at sharp sight provokes the compensating action of the ciliary muscle. This reflex activity of the accommodative apparatus may overreach its aim, and raise the apparent refraction to a higher degree than is of service in the special case. Thus a slight astigmatism, either myopic or more often hypermetropic, may be converted into apparent M. by ciliary contraction. But in such instances the ophthalmoscope decides at once the real state of refraction, as long as the patient makes no effort to see distinctly during the time of examination. This instrument, however, cannot distinguish between M. and real tonic spasm of accommodation, and in any such doubtful cases the diagnosis must be made by comparing the refraction before and after paralysis by atropine.

Instances of real ciliary spasm are rare. According to general experience, as well as my own, ciliary spasm may be brought on by severe eye strain, especially in slightly hypermetropic or astigmatic eyes, and sometimes by slight injuries to the eye. I, at least, have never seen it occurring in genuine M. A few instances have been observed in the course of nervous diseases, among them one by the writer after a hemiplegic stroke.[3] Such ciliary spasm may give rise to fatigue and other asthenopic symptoms, while in other cases nothing is complained of but the indistinctness of sight. The spasm of accommodation resulting from eye strain is completely removed by the instillation of atropine solution (or any of its substitutes), and will generally not return if the eyes are rested. In other cases, especially those of nervous disturbances, the use of a drug paralyzing the ciliary muscle may have to be repeated for a variable length of time in order to restore the natural condition.

Ciliary spasm has been claimed, by Dobrowolsky[4] and various other authors, to be a frequent complication of M., and, indeed, to be an important factor in the origin and growth of short-sightedness. It has been asserted that in many cases of M. the refraction is lowered by the action of atropine, and that it sometimes requires the prolonged use of this drug in order to learn the real state of

refraction. No direct proof, however, has been offered that this alleged spasm increases the refraction permanently, and its influence on the progress of M. is a mere hypothesis.

Most of the cases cited by Dobrowolsky and others ought really to be referred to the physiological tonus of the ciliary muscle. The use of atropine reduces the refraction to the extent of 0.5 to 0.75 D. in most eyes, whether they be myopic, emmetropic, or hypertropic, and this change can be recognized by means of the ophthalmoscope as well as by subjective tests with glasses.*

This tonus does not exist in all eyes, but its presence in the majority of cases, without annoyance or demonstrable evil influence of any kind, shows it to be a normal occurrence. Hence a reduction of refraction of less than one D. on atropinizing in M. cannot be claimed as indicating a morbid condition peculiar to M. The alleged ciliary spasm which the defenders of the accommodation theory of M. have observed rarely exceeds 1 D. Hence the view that M. is influenced by such spasm of accommodation cannot be based upon the frequent association of the two anomalies. In my own experience,† comprising not far from one thousand cases of M., I have never seen a typical spasm of accommodation complicating M. which (according to the previous definition of ciliary spasm) could not be determined ophthalmoscopically. I have formerly atropinized nearly every case of M., quite often using the drug a number of times. Later on I have employed homatropine instead, having assured myself that three to five instillations of the two per cent. solution produce as much effect as atropine, while its action, lasting only during the same day, is less annoying to the patient. But I have seen no confirmation of the accommodative theory of the origin of M. Excessive action of the ciliary muscle, apparently increasing the M. during efforts at sight and trial with glasses but relaxing during the ophthalmoscopic examination, I have met with occasionally, but not very often, in simple M. Almost all these cases had unequal refraction in the two eyes, which inequality I must hence consider as a cause of over-action of the ciliary muscle. But in the immense majority of examinations in M., even where the refraction was not alike in the two eyes, I have found no anomaly of accommodation. In M., however, complicated with astigmatism, ciliary over-action is almost the rule. Yet these are the very cases which, according to my experience, show least tendency to progressiveness.

Course and Frequency of Myopia.—The importance of myopia as a public evil, on account of its inconvenience, its influence on sight, and the danger to which it subjects the eye in its higher grades, is all the greater on account of its frequency. Shortsightedness is one of the evils of modern civilization, and its distribution depends, to no slight extent, on the present modes of higher education. Congenital nearsightedness is probably quite rare, since in infants' eyes the myopic refraction is the exception. A statement to the contrary was formerly made by Jaeger,[5] who found, ophthalmoscopically, in 100 babes 78 instances of M., 17 of H., and but 5 of E. All later observers, however, agree that the prevalent refraction shortly after birth is H., but that it requires the use of atropine, which Jaeger did not use, in order to determine it correctly. It has even been noted that the atropine solution must be used quite thoroughly in order to exclude accommodative action in babes. Ely[6] found, in 154 atropinized eyes of infants soon after birth, 27 M., 21 E., and 106 H. A still smaller percentage of M. was counted by Koenigstein, Schleich, Ulrich, and Bjerrum; and none at all by Germann,[7] in 85 babes. Horstmann[8] gives the following statistics of 100 atropinized eyes in each of three series, the first being babes between the eighth and thirtieth day; the second, infants of one to two years; and the third, children of four to five years of age:

	M. 3 D.	M. 2 D.	M. 1 D.	E. 0.	H. 1 D.	H. 2 D.	H. 3 D.	H. 4 D.	H. 5 D.	H. 6 D.
Infants between the 8th and 30th day ...		2	.	10	16	16	36	14	4	2
Infants between the 1st and 2d year	.	2	4	10	24	32	18	6	2	2
Children 4 to 5 years of age	2	5	6	13	18	26	16	8	4	3

This table shows strikingly how the refraction increases during childhood, both by the diminution of the percentage of H. and the growth of M. in number and degree.

The eyes of school-children have been examined statistically by numerous observers, whose results agree in the main. There are now on record the figures obtained from over 150,000 scholars. The results show that M. increases steadily from the lower to the higher classes, both in percentage and in the average of its degree. Hypermetropia, on the other hand, diminishes as the pupils advance in grade, but not in the same proportion as M. augments, for many cases of apparent E. prove to be latent H., as the children grow older and lose part of their range of accommodation. Moreover, an eye which is still markedly hypermetropic at the time school is entered is not as likely to change to M. as the emmetropic organ. The variations in the figures found by different examiners are due partly to the conditions of the children, their nationality, and descent, as well as to unavoidable accident, wherever the total number examined was not a very large one. There is also a difference in the limit assigned by different authors to E., some including in E. all myopes and hypermetropes of less than 1 D., while others recognized M. when a glass of 0.5 D. was found to improve vision. Some examined subjectively, with reading-test and trial-glasses, while others relied on the ophthalmoscope.

Cohn[9] furnishes the following table, based on the examination of 10,060 children. The refraction was determined subjectively, and without the use of atropine, all H. and M. of less than 1 D. being reckoned as E. The school grades are stated in black figures, 1 being the highest. The number of classes varies, of course, with the kind of school. The schools are in the City of Breslau, except the country schools.

Percentage of Myopia.

School.*	No. of pupils.	In Grade. 8	7	6	5	4	3	2	1
Five country schools	1,486	..	..	..	..	..	1	2	3
Twenty city elementary schools.	4,978	..	..	..	..	..	3	4	10
Two advanced schools for girls..	834	1	2	7	8	6	16	12	19
Two grammar schools..	426	..	..	0	10	6	13	9	15
"Realschule" (z. heil. Geist.) ..	502	..	..	7	12	25	27	25	59
"Realschule" (z. Zwinger).....	639	..	..	11	21	13	23	28	29
Gymnasium (Elisabeth)	532	..	..	11	17	19	31	48	65
Gymnasium (Magdalenen)	663	..	..	14	19	28	30	35	47

The numerous reports of school examinations by other authors confirm, without exception, Cohn's results. They all show a steady increase of M. on advancing from class to class. Where irregularities or exceptionally high or low figures occur, they are occasioned by accident among a number of scholars too small for statistical purposes. As the result of the examination of 9,344 boys in 24 German "Gymnasia" and "Realschulen," by various observers, Cohn gives the following figures, ranging from the lowest to highest grades, viz., 22, 27, 36, 46, 55, and 58 per cent. of M. The refraction of girls was found about the same as that of boys in the corresponding school-grades.

In this country, examinations have not been made as

* Investigations on the eyes of infants by Jaeger, Ely, and many others, seem to show that in many cases there exists, soon after birth, a tonus of the ciliary muscle which may amount to several D., and which makes the eye appear myopic on ophthalmoscopic examination. The very frequency of this occurrence in infantile eyes, most of which are hypermetropic, proves that it has no bearing on the present question.

† My experience is fully corroborated by a very thorough school examination under the influence of homatropine by Duerr.[10]

* The German "Gymnasium" is the preparatory school for the university, comprising largely a classical course and exacting very much work of the pupils. The "Realschule" teaches less classics and more science; its pupils enter and leave at younger on an average than in the Gymnasium. The advanced schools for girls correspond to our female seminaries, but have a less extended course.

extensively as in Germany, but as far as they go they show a similar increase of M. with advancing education, though the total number of myopes may be somewhat less than in European countries. Agnew[10] reports statistics gathered by Ayres and Williams, in Cincinnati, showing: Ten per cent. M. and 83½ per cent. E. among 209 children in district school; 14 per cent. M. and 80 per cent. E. among 210 children in intermediate school; 16 per cent. M. and 78 per cent. E. among 210 children in high school. In New York, there were found by Prout and Mathewson, among 549 college-students: Twenty-nine per cent. M. and 57½ per cent. E. in the introductory class; 40 per cent. M. and 42½ per cent. E. in the freshman class; 40 per cent. M. and 42½ per cent. E. in the sophomore class; 56 per cent. M. and 37 per cent. E. in the junior class; 37 per cent. M. and 50 per cent. E. in the senior class. Among 300 students in the Brooklyn Polytechnic Institute, academic department, they found 10 per cent. M. and 56 per cent. E., but among 158 boys in the collegiate department, 28½ per cent. M. and 53 per cent. E. Loring and Derby[11] examined New York schools, both ophthalmoscopically and with trial glasses, including in M. the lowest degrees down to $\frac{1}{60}$. Their percentage was, among scholars six to eight years of age, 3.55 per cent. M.; nine to ten years of age, 5 per cent.; eleven to twelve years of age, 10 per cent.; fifteen to sixteen years of age, 15 per cent.; seventeen to eighteen years of age, 20 per cent.; eighteen to nineteen years of age, 25 per cent.; twenty to twenty-one years of age, 26.8 per cent. On classifying the scholars according to their descent, they found 24 per cent. M. among children of German parentage; 20 per cent. M. among children of American parentage; 14 per cent. M. among children of Irish parentage. Among 457 negro children, in New York schools, of the age of five to nineteen years, Callan[12] counted but 12 myopes, equal to 2.6 per cent. These variations in the frequency of M., according to race or nationality, constitute a forcible argument in favor of an hereditary disposition. In the public schools of Philadelphia, Risley[13] found an average of 13.7 per cent. M., 11.2 per cent. E., and 74 per cent. H. in all classes together. The proportion of M. increased here, as well as elsewhere from grade to grade, but the total frequency was less than in European schools.

In Chicago an examination of scholars in public schools, by W. F. Smith,[14] showed,

Among	220	eyes of	pupils	of the age of	6 to 8	years,	4.09 per cent.	M.
"	230	"	"	"	8 to 10	"	5.65	" M.
"	346	"	"	"	10 to 12	"	10.98	" M.
"	814	"	"	"	12 to 14	"	12.89	" M.
"	204	"	"	"	14 to 15	"	16.17	" M.

and in the high school,

Among	242	eyes of	pupils	of the age of	15 to 16	years,	17.76 per cent.	M.
"	245	"	"	"	16 to 18	"	23.26	" M.
"	79	"	"	"	18 to 19	"	25.31	" M.
"	48	"	"	"	19 to 20	"	27.08	" M.

The average degree of M. advances during school attendance, as well as does the number of myopic eyes. But since the percentage of high M. is not very large compared with the lower degrees, and since in every higher class of school fresh cases of incipient M. are found, a mathematical average does not convey the full importance of the progress of the anomaly. More striking are the results of Cohn on re-examining the scholars in a Breslau gymnasium in 1871, after an interval of one and a half year. Of the number previously tested there remained 84 pupils, whose refraction had been emmetropic, and of whom 14 = 16 per cent. had become myopic, while of the 54 cases of M. previously noted, 28 = 52 per cent. had increased in M. The average degree of these myopes had risen from $\frac{1}{36}$ to $\frac{1}{14.6}$.

H. Derby[15] traced the refraction of 254 students from their entrance in Amherst College, at an average age of nineteen years, until their graduation four years later. On entering there were 39 cases of H., of which 1 changed to M., 2 diminished in H., 27 remained stationary, 9 increased in H.; 125 cases of E., of which 29 changed to M., 86 remained stationary, 10 changed to H.; 90 cases of M. (35.47 per cent.), of which 32 remained stationary, 58 increased in M.; and thus the percentage of M. increased to 47.2 per cent. in four years.

The distribution of M. throughout the population, and its dependence on school education and eye-work is well shown by statistics gathered among recruits, in countries where military service is compulsory. The recruits are all of the age of eighteen to twenty years. Seggel[1] classified 1,810 Bavarian recruits according to their occupation and social rank as I., farmers;* II., laborers; III., artisans and musicians; IV., volunteers, who must have passed a high examination in order to enter as privileged soldiers; including also in class IV. occupations taxing the eyes, like type-setting. Drawing the line between M. (or H.) and E. at $\frac{1}{12.5}$, he found,

	E. Per cent.	H. Per cent.	M. Per cent.
In Class I.....	78.3	19.7	2.0
" II.....	71.4	25.5	3.1
" III.....	70.5	21.0	8.5
" IV.....	35.8	6.7	57.5

Very valuable statistics have been collected by Tscherning[16] in Denmark. He divided his material at the examinations for the army into six classes, including in I., university students; II., bookkeepers and merchants doing office work; III., educated people, like civil engineers, architects, actors, etc., who have not passed a university course (in Denmark); IV., artisans engaged in fine work; V., artisans doing coarse work; and VI., laborers, farmers, and sailors. He examined ophthalmoscopically, and included under the head E. all M. and H. of less than 1 D., which limit makes his figures for M. apparently small. Tscherning observed a percentage of M.

				Of 2 D.	3 to 6 D.	7 to 9 D.	Over 9 D.	Total M.	E.	H.
Among	491	men	in Class	I...	6.8	20.3	4.2	1.0	32.3	63.7	3.8
"	1,009	"	"	II..	3.8	8.9	2.2	0.6	15.7	79.6	4.5
"	270	"	"	III.	4.0	7.4	1.8	0.0	13.3	85.5	1.1
"	566	"	"	IV.	4.0	6.3	1.0	0.2	11.6	84.2	4.0
"	2,861	"	"	V..	1.3	2.5	0.5	0.8	5.2	89.7	5.0
"	2,326	"	"	VI.	0.7	0.8	0.2	0.6	2.4	94.7	2.5

These figures show strikingly the increase of M. with the greater application of the eyes during youth. According to Tscherning the degree of M. principally influenced by eye work, is comprised between 2 and 9 D., and more especially between 3 and 6 D. Myopia below 1 D. he did not attempt to separate from E., and he regards it as a structural type of eyes equally common in all classes of the population, and not influenced at all by eye-work. Excessive M., above 9 D., was found in about the same small proportion throughout the entire population, and this form is hence considered by Tscherning as a progressive disease, not at all dependent on the use of the eyes.

The ultimate course of M. with the advance of life cannot be learned from school or military statistics, but only from professional experience. Donders has pointed out three types of M. according to its progress, viz., the stationary form, the temporarily progressive form, and the permanently progressive variety. The stationary form of M. deserves its name only as judged after the age of puberty. Not being congenital in the great majority of cases, it begins at some time between the eighth and twelfth years of life and increases slowly, to become really stationary between, perhaps, the fifteenth and twentieth years. It is mostly of a lower degree than about 2.5 D., but may exceptionally amount to more, even to 6 D. The temporarily progressive form, when detected at the age of, perhaps, ten or twelve years, has already reached several D., and attains its limit of perhaps 4 or 6 D. at about the thirty-fifth year of life. The permanently progressive form of M. begins early in childhood, has usually reached over 5 or 6 D. before the

* The farming population in Europe has not the literary ambition found in this country, although attendance at elementary schools is compulsory.

twentieth year, and continues to increase steadily during the greater part of life. These types intermingle, so that no sharp limit can be drawn between them.

A myopia which ceases to progress after the age of puberty can be considered as an inconvenient, but not dangerous, anomaly of the structure of the eye. Short-sightedness, however, of a permanently progressive course is more than an inconvenience, it is a morbid change involving great danger to the integrity of the eye, and the more marked its progress and the higher the degree it has reached, the greater is the chance of its leading to destructive complications. In the forms of M. intermediate between the stationary and the progressive types, it is often difficult to form a judgment of their probable course, especially when seen during earlier life. The most reliable criterion in such cases is the past history of its progress. For the more malignant the type of M., the more rapidly will it continue to change, even after the growth of the body has ceased. Below 6 D. myopia leads very rarely to disastrous results. Tscherning even considers the limit of malignancy at about 9 D., as based upon his extensive investigations, but which figure most oculists would regard as too high.

Diagnosis and Measurement of M.—Short-sightedness is such a common and well-known complaint that patients usually come with their own diagnosis. In order to confirm this the sight of the patient is tested with some form of test-types, at a distance greater than ten feet. If the visual acuity is found normal, M. greater than 0.5 D. can be excluded. If the sight does not reach the average standard concave glasses are tried, passing from the lower to higher numbers, until the weakest glass is found which gives the best possible sight, the number of which glass gives the numerical degree of the M. It is, of course, necessary to test each eye by itself, the other being covered. Some uncertainty may arise from the hesitation of the patient as to which he considers the best glass in high grades of M., on account of the reduced sight. A similar error is possible in M. complicated with astigmatism, in which case the patient's answer may vary from moment to moment, until the proper cylinders are added. A mistake in another direction can sometimes occur, in cases of corneal opacity, in which concave glasses, by causing an accommodative effort accompanied by contraction of the pupil, may improve vision by diminishing the amount of scattered light, though the eye be not myopic at all.

The observer can make himself independent of the patient's answers by the use of the ophthalmoscope in the direct image. It is advisable to begin every examination with this instrument, which informs us, moreover, of the existence of any complications. An emmetropic observer, who relaxes his accommodation, sees sharply all details of the fundus of any emmetropic eye which he views through the ophthalmoscopic mirror in the direct image. If the examined eye be hypermetropic, the observer must correct the deficient refraction by means of convex glasses, or by using his accommodation. But if the eye viewed be myopic, the retinal vessels and the edge of the papilla will appear indistinct to him in proportion to the degree of M. In order to get a sharp image he must correct the M. by the proper concave glass, placed behind the mirror. The weakest glass enabling him to see the fundus sharply, indicates the degree of M. It is necessary, however, to approach the observed eye as closely as possible, otherwise the reciprocal of the distance ($\frac{1}{d}$) must be subtracted from the number of the glass. If the observer himself is ametropic, the correcting glass required is the algebraic sum of the glasses needed by both the patient and the oculist for distant vision. Thus, if the observer is himself myope the number allowing him to see the fundus of the patient sharply is = M. (of the examined eye) + M. (of the observer); while if he be hypermetropic he must make use of a lens equal to M. (of the examined eye) − H. (of the observer), provided he can relax his accommodation. If he cannot do this no accurate measurement can be made. With moderate skill the refraction can be determined ophthalmoscopically, within an error of less than one D. In astigmatism, however, it requires exceptional skill to attain this accuracy. A discrepancy is often observed between ophthalmoscopic and functional measurement, not due to any error in either method, but dependent on an actual difference in the two ocular diameters measured. For the patient seeks the glass which gives him the sharpest image on the fovea centralis, while the observer is more apt to examine ophthalmoscopically a region characterized by details, like the edge of the papilla, which often does not bulge out as far as the region of the fovea centralis.

Another method of determining the refraction ophthalmoscopically with tolerable accuracy is by means of the shadow test (also termed retinoscopy and keratoscopy). On throwing light into an eye with the ophthalmoscopic mirror at some distance from the eye, the pupil appears to the observer illuminated in its entire extent, if the mirror be so held that the centre of the illuminated image upon the retina lies in the line joining the centres of the pupils of the patient and observer. If, by tilting the mirror slightly, we cause the image of the light to move on the retina as far as the size of the pupillary aperture permits, the pupil will no longer be illuminated in its entire extent, and the bright field will now be limited by a black shadow. As long as the observer stations himself between the examined eye and its far point, the shadow adjoining the bright pupillary reflex moves in the same direction in which he projects the light reflected from the mirror by tilting the ophthalmoscope. This congruous movement of light and apparent shadow occurs always in E. and H. In M., however, the shadow will move in the opposite direction from the light as soon as the observer recedes beyond the far point of the short-sighted eye which he examines, on account of the formation of an inverted aerial image of the retina at this far point. But if the observer places his own eye exactly at the far point of the eye under examination, the tilting of the mirror will not cause any shadow to appear in the pupil at all, as long as any of the rays from the mirror enter the pupil. The distance between his and the patient's eye now corresponds to the degree of the myopia. In astigmatism the far point of each meridian can be ascertained by tilting the mirror in the plane of the meridian examined.

Pathology and Etiology.—The disproportion between the refractive power of an eye and the position of its retina, which constitutes M., may be due to too high a refraction in an eyeball of average length, or to an excessive length of the eye with average curvature of the refracting surfaces, or to both structural anomalies combined. It requires but little deviation from the average standard of curvatures in Helmholtz's diagrammatic eye (comp. art. on Accommodation and Refraction), or from the distances between the surfaces, to change the focal length of the eye appreciably. Even in the emmetropic eye, the average of one or the other of the optic constants is often deviated from, in one or the other directions, to an extent which would move the focus far from the plane of the retina, were it not for the mutual compensation of these irregularities. Ophthalmometric measurements of myopic eyes made by Donders,[18] Mauthner,[19] v. Reuss,[20] and many others, have, however, not shown any characteristic deviation from the emmetropic type in the curvature of the corneal and lenticular surfaces.*

When M. is hence due to an improper balance in the construction of the different parts concerned in refraction, it must be regarded as an accident of growth, and such short-sightedness is therefore a harmless inconvenience.

* The following table gives the figures taken by Helmholtz as the basis of the schematic emmetropic eye:

	mm.
Radius of curvature of cornea	7.829
Radius of curvature of anterior surface of lens	10.000
Radius of curvature of posterior surface of lens	6.000
Depth of anterior chamber	3.600
Thickness of lens	3.600
Length of optic axis from cornea to fovea centralis	22.834

These figures represent the values most commonly found on actual measurement up to the time of Helmholtz's publication, and the posterior

It would be desirable to be able to distinguish between this form of *refractive M.* and the short-sightedness dependent on elongation of the axis of the eyeball, *axial M.*, as we may call it. There exist, however, no means of measuring the length of the eyeball during life, at least when the lens is present; while the methods for the determination of the optic structure of the refracting parts are too difficult for practical use. The writer has found that some reliance may be placed on the use of the following principle of distinction between these two forms of M. The elliptic shape of the cornea, and still more so the laminated structure of the lens, give to the posterior focal plane of the eye a curvature practically coinciding with the curvature and position of the retina in emmetropia.* On looking into an emmetropic eye with the ophthalmoscope, the vessels and other details of the retina appear as sharply defined at the extreme periphery as they do in the centre of the retina, or at the entrance of the optic nerve. If such an eyeball were elongated in the antero-posterior direction, and not in its other diameters, the periphery of the retina would appear to us as distinctly as in the previous case when seen through the mirror, while the middle of the retina, being beyond the focus of the examined eye, is seen blurred, unless the suitable concave glass be employed. This very observation can be made in the majority of short-sighted eyes. On the other hand, myopic eyes will sometimes present an equally indistinct view, whether the ophthalmoscope be directed toward the extreme anterior zone of the retina yet visible, or toward the posterior pole of the eyes, and the same correcting glass is required in order to see distinctly any part of the retinal surface. In these instances the refracting surfaces are evidently at fault, while the retina describes the normal curvature. Such pure cases of refractive M. I have not seen very often, perhaps because I searched for them only in office practice. They were all low degrees of M., rarely above 1 to 2 D. More commonly has the ophthalmoscope shown the existence of axial M., with some slight addition of refractive M., as indicated by a difference in the strength of the correcting glasses behind the mirror required for examination of the central and, on the other hand, of the more peripheral retinal region.

The dissections made by Jaeger,[5] Donders,[18] and others, of eyes afflicted with axial M., have shown that the antero-posterior diameter is lengthened, in extreme cases, up to thirty-two millimetres. The eyeball has assumed an oval shape. The greatest elongation is not necessarily in the line of the visual axis. In some instances the entrance of the optic nerve bulges out more prominently even than the region of the posterior pole. The bulging part of the sclerotic tunic is thinned, sometimes to such an extent as to be translucent. Its structure is rarefied. But beyond this no morbid change has been described as occurring in the sclera, and no evidence of inflammation has been detected. Two possible explanations of this change suggest themselves. Does the sclera yield passively to distention caused by an augmented intra-ocular pressure, or is the starting-point to be sought in a diminished resistance of the sclerotic coat? The former view cannot be maintained, because the intra-ocular pressure is not above the average in ordinary M. Moreover, in the disease characterized by an elevated pressure in the interior of the eye, viz., glaucoma, it is not the sclera which yields, but the distention and bulging are limited entirely to the entrance of the optic nerve, where the firm sclera is deficient and its place taken by the less resistant lamina cribrosa. On the other hand, however, neither theoretical reasoning nor microscopical investigation have taught us why, and under what circumstances, the sclerotic tunic should lose its normal power of resistance and undergo this atrophic change in M.

The elongation of the eyeball is usually accompanied by intra-ocular changes visible with the ophthalmoscope. In about twelve per cent. only of myopic eyes these changes are not found, and the inspection during life shows a perfectly normal fundus. The most common change seen in myopic eyes is the *crescent* or *conus* surrounding the optic papilla. This appears in the form of a crescentic white figure hugging the optic disk, with which it is continuous. Its convex border is generally marked by an accumulation of black pigment, sometimes in the form of a thin continuous edge lining it, sometimes only in scattered spots. In other instances the pigmentary stripe is absent. The conus or crescent, in its smallest forms, may surround only about one-third of the circumference of the optic disk, and have the width of perhaps one-tenth the papillary diameter, while in other instances it is found enlarged to one and one-half time, or even twice, the width of the disk, encompassing the latter in the larger part of its periphery. In extreme cases the conus forms an ovoid figure, in the interior of which the entrance of the optic nerve is situated excentrically. The retinal vessels can be seen crossing the conus in their ordinary mode of distribution. The crescent is found at the temporal side of the optic disk, toward the fovea centralis, in about ninety-five per cent. of its occurrence. In rare instances it may be seen on the inner, upper, or lower side of the papilla. These anomalous crescents are almost always small. Whenever a crescent is small, its convex edge is sharply defined, while the larger coni often show an irregular outline. On account of this and other differences between the smaller and larger forms, there is reason to suspect that the term crescent includes two conditions of different significance.

The term posterior staphyloma is often used in speaking of the lesion in the rear part of the myopic eyeball. Literally, this name staphyloma refers to any berry-shaped or grape-like bulging of the eye, and it is ordinarily used in this sense in speaking of the partial distention of the front of the eyeball as the result of disease. But the

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focus of this diagrammatic eye corresponds exactly to the plane of the fovea centralis. On measuring a large number of eyes, v. Reuss [20] found the following deviations from these averages:

	H.	E.	M.
	Min.–Max.	Min.–Max.	Min.–Max.
Corneal radius in millimetres.	7.27– 7.53	7.00– 7.73	7.00– 8.00
Radius of ant. surface of lens.	10.89–12.41	9.37–11.84	9.61–14.66
Radius of post. surface of lens.	6.74– 8.65	7.11– 9.45	7.06–11.33
Depth of ant. chamber.....	2.47– 3.28	2.84– 3.23	3.08– 3.86
Thickness of lens	3.31– 4.10	3.50– 4,19	2.96– 3.67

The degree of M. produced by any increase in the convexity of any of the refracting surfaces can be computed on the basis of the schematic eye. In order to calculate the optic effect of any change in the corneal curvature, we can compute the number of dioptrics which the eye would represent with a given radius of curvature of the cornea, and the actual index of refraction of cornea and aqueous and vitreous humor = 1.3365, and compare this figure with the refractive power of the schematic eye (the lens can be ignored in this calculation as irrelevant). Thus, a corneal radius of 7.829 mm. gives a focal length (F_{11}) = 31.095 for the corneal refraction, equalling a lens of $\frac{100 \text{ cm.}}{F_{11}} = 32.1$ D. If we deduct this value from the results of different corneal radii, we find a corneal radius of 7.5 mm., causing M. of 1.4 D.; a corneal radius of 7.25 mm., causing M. of 2.6 D.; a corneal radius of 7 mm., causing M. of 3.8 D.

If the corneal radius be considered a trifle too long in Helmholtz's diagrammatic eye, this error is more than compensated for by taking the radius of the anterior surface of the lens somewhat too small, as compared with v. Reuss's measurements. Moreover, the length of the eyeball is perhaps a little below the average in the diagrammatic eye. Various measurements of eyeballs, known as emmetropic during life, give a value of 23 to 24.1 millimetres for the optic axis from cornea to fovea centralis (quotations in Nagel's [21] and Mauthner's [19] works). The elongation of the eyeball in M. can be calculated from a knowledge of the far point (if we assume the eye to be otherwise identical with the schematic eye). If we term l_1 the distance between the far point and the anterior focus of the eye (F_1 = 15.502 mm.) and l_{11} the elongation, that is to say, the distance between fovea centralis and posterior focus (F_{11} = 20.719 mm.), then

$$l_{11} = \frac{F_1 F_{11}}{l_1}.$$

Such calculations furnish the following table:

		mm.			mm.
M. of 0 D.	corresponds to an axis of	22.834	and to an elongation of		0.000
" 0.5	" "	22.995	" "		0.161
" 1	" "	23.160	" "		0.326
" 2	" "	23.496	" "		0.662
" 4	" "	24.203	" "		1.369
" 6	" "	24.968	" "		2.134
" 10	" "	26.635	" "		3.801
" 15	" "	29.116	" "		6.285
" 20	" "	32.143	" "		9.309

* Stammeshaus has mostly found a slightly hypermetropic refraction on looking ophthalmoscopically at the retinal periphery.

atrophic changes of the character just described as conus do not necessarily indicate that any such circumscribed bulging exists in that region. It would be better, therefore, to speak of staphyloma only when ophthalmoscopic measurement shows a higher refraction in the region of

FIGS. 2421, 2422, AND 2423.—Different Types of Crescents. (After Jaeger.)

the crescent than in the rest of the fundus, indicating an actual circumscribed bulging in this part.

Dissections of myopic eyes, principally by Jaeger and Donders, have shown that the pigment epithelium layer of the retina is entirely absent throughout the conus, no vestige of the epithelial cells being found. The choroid coat itself is atrophied * within the crescentic region, but is always represented by some remainders of it. Its pigmented cells have disappeared, with the exception, perhaps, of a few scattered remnants. The layer of capillaries could not be found, but the larger vessels could in all cases be detected, though their calibre had been so narrowed that most of them contained scarcely any blood. The pigment surrounding the conus is extra-cellular and situated in the choroid, and such remnants of coloring matter, with disappearance of the cells wherein they were formerly contained, are found scattered throughout the central part of the choroid. This tunic is further thinned by atrophy in the entire region in which the sclera has yielded, its thickness being least in the very spot where the sclera is thinnest. But except within the crescent none of the choroidal layers is actually absent. The irregular distribution of extra-cellular pigment, and the partial diffuse atrophy of the pigment epithelium throughout the fundus give rise to a mottled appearance of the fundus, which the ophthalmoscope shows often in myopic eyes.

The crescent thus depends upon the circumscribed absence of the retinal pigment epithelium, together with an atrophy of the choroid tissue and disappearance of its pigment. The whiteness of the conus is the color of the exposed sclera. The larger crescents with irregular outline do not always appear as blanched white as the small ones, their pinkish tinge resulting from the blending of the narrowed but still pervious choroidal vessels with the scleral color in the ophthalmoscopic image.

In a case examined by the Duke Carl Theodore of Bavaria,[22] the layer of rods and cones of the retina was found wanting throughout the crescentic figure. This fact has an important bearing, since the absence of the sensitive layer of the retina must increase the size of the blind spot beyond the limits of the optic disk. This fact, first pointed out by Donders, was more fully confirmed by Schnabel,[23] who tested the retinal sensitiveness by causing the ophthalmoscopic image of a minute source of light to wander over the retinal zone around the disk, while the patient stated whether he perceived it or not.

The appearance of the crescent is not limited to myopic eyes. It has been counted in about sixty per cent. of emmetropic and hypermetropic eyes of school-children by Weiss, who included, however, in this number all deviations, no matter how slight, from the typical appearance of the optic disk and fundus. Loring,[11] who limited the term crescent to the well-pronounced figure between disk and fundus, found it in only 3.49 per cent. of H., 3.33 per cent. of E., but in 20.5 per cent. of M., the discrepancy between his figures and those of Weiss depending on the different limitation of the term as to minute deviations by the two authors. The conus can be seen in some non-myopic eyes at an age so far advanced that a change to M. is no longer to be expected, and, on the other hand, occasionally in the eyes of hypermetropic infants.

Schnabel[23] has advanced the view that in many instances the conus is congenital, and that in that case its existence does not imply atrophy of the ocular walls, but arrest of embryonal development. The occurrence of such crescents in eyes not myopic shows that its association with short-sightedness is not absolute. The view is confirmed by the absence of the conus in some cases of unmistakable axial myopia. The majority of crescents, however, are acquired, and their gradual growth can often be watched on examining myopes at long intervals of time. Indeed, the average size of crescents increases approximately with the degree of M., while in H. and E. it is scarcely ever large. The mode of origin of these acquired crescents is not securely established. It seems likely that the following mechanical explanation applies in some, if not all, instances of both acquired and congenital small crescents.

When an eyeball becomes elongated the pressure of the vitreous body against the retina and choroid maintains the normal contact between the latter tunic and the sclera. The sclera, however, gives way unevenly, the apex of its prominence yielding most, as the greatest thinning in that region indicates. The choroid, in following the bulging of the sclera, is subjected to a traction throughout its entire extent up to the ciliary region, where it is

* The descriptions by these authors refer only to large crescents in high degrees of myopia.

most firmly attached to the sclera.* This traction of the choroid in the posterior direction causes a shearing of the optic nerve where it penetrates the walls of the eyeball. The trellis-work supporting the optic papilla consists of the firm lamina cribrosa, the fibres of which are continuous with the fibres of the sclerotic (perhaps, also, of a more delicate fibrillar network continuous with the choroidal tissue). At the spot where the nerve perforates the ocular walls the choroid coat forms a free border in the shape of a firm fibrillar ring surrounding the entering nerve. This choroid ring is displaced in M. toward the fovea centralis by reason of the traction to which the choroid is subjected at the posterior pole, and drags with it the inner surface of the optic disk. Such displacement can often be detected with the ophthalmoscope. The median edge of the papilla is found encroached upon by a more or less delicate crescentic or sickle-shaped pinkish veil, which forms the counterpart of the white crescent on the outside of the external border of the papilla, as seen in Fig. 2422. This pinkish veil consists of the unpigmented stroma of the choroid dragged toward the posterior pole. In other instances the portion of choroid pulled over and partly covering the internal edge of the papilla is partly, or even completely, pigmented, and causes the optic disk to appear narrowed in the horizontal direction, its true median edge not being visible ophthalmoscopically. In consequence of this displacement the central vessels of the retina emerge from the disk apparently nearer its median edge than ordinarily.† The

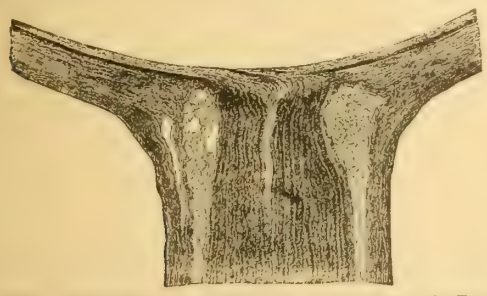

FIG. 2424.—Transverse Section through the Optic Nerve at its Entrance into the Eye. (After Jaeger.)

conus seen on the external side of the disk in this case implies that the choroid proper has retracted from the papillary edge of the sclera, leaving the sclera covered only by the retina. A transverse section through the optic entrance of such an eye shows a flattening of the curve described by the optic fibres as they pass into the retina on the temporal side of the disk, while on the median side the nerve-fibres make a sharp bend around the projecting choroidal border in order to reach the plane of the retina.

The mechanical displacement of the choroidal ring, and retraction of the choroid from the scleral border of the lamina cribrosa, seems a sufficient explanation of all the smaller crescents, at least those with sharply defined edges. Even where no special bulging exists at the posterior pole, such a gliding of the choroid on the sclera may take place whenever the antero-posterior diameter of the eyeball grows at any time more rapidly than the other diameters. Hence this occurrence accounts for the small coni found often in hypermetropic or emmetropic eyes, either congenitally or acquired during infancy, for the collective examinations previously referred to show that in most eyes the refraction increases during childhood.

The small conus due to displacement of the choroid at the level of the lamina cribrosa is hence not absolutely characteristic of M., but indicates that at some period of life the growth of the posterior part of the sclera has exceeded the rate of growth of the choroid tunic, and that the latter has been subjected to traction in consequence. Whether such an eye becomes myopic during the period of elongation of the visual axis, depends upon the changes in the curvature of the cornea and lens accompanying this growth of the eyeball in the antero-posterior direction.

The conus, however, attains quite commonly a larger size in progressive M. than corresponds to the space exposed by the retraction of the choroidal border from the lamina cribrosa in the manner just described. Its growth cannot be due to mere stretching of the choroidal ring, since within the crescentic region the microscope will always reveal the choroidal stroma, however much atrophied. It is evident, therefore, that the further growth of the crescent beyond the sickle-shape due to choroidal displacement depends on retraction of the retinal pigment epithelium, as well as atrophy of the choroid tissue. These large crescents with irregular outline and remnants of choroidal vessels are characteristic of progressive M., and depend on the yielding of the sclera in a manner not yet fully explained. The difference between the small coni of mechanical origin and the atrophic crescents is often indicated by the dead-white color of the former, and their sharp, circular outline as contrasted with the more reddish tinge, scattered pigment marks, and irregular contour of the latter.

The space between the external and internal sheaths of the optic nerve, which are normally in close contact, has been found widened in axial M. A cross-section through the entrance of the optic nerve, in such an eye, shows a club-shaped, or triangular dilatation of the intervaginal space where the sheaths merge into the sclera, caused by retraction of the external sheath, as seen in Fig. 2424.

The traction upon the choroid tunic by reason of its following the scleral bulging extends up to the ciliary region, which in high grades of M. is flattened, while its processes are thinned (Duke Carl Theodor). The ciliary muscle is described by Iwanoff as being thinner and atrophic on comparison with emmetropic eyes, the circular fibres being specially involved. Whether the diminished use of the accommodative apparatus in uncorrected M. accounts for this atrophy or whether this is another result of the traction upon the choroid is an open question. The elongation of the entire eyeball reveals itself often in the greater depth of the anterior chamber in M.

The vitreous body can become partly detached from the internal limiting membrane of the retina in progressive M., its growth being insufficient to fill out the interior of the elongating eyeball. An effusion of fluid takes place between the vitreous body and the central region of the retina. This has been anatomically demonstrated by Weiss.[24] The same observer states that this occurrence can be recognized ophthalmoscopically as a ring-shaped bright stripe (or segment of such) surrounding the papilla ("Reflex-bogenstreif") but anterior to it, and hence seen only when the eye of the observer is accommodated for a plane in the vitreous somewhat in front of the retina. This appearance is caused by the (total) reflection of the light thrown in by the mirror at the junction of the optically denser vitreous and the fluid effusion of less refractive index. The bright circle is not readily detected, requiring a tilting of the mirror at a certain angle, to be found by trial. But, on the other hand, Weiss regards this optic figure as one of the earliest signs of lengthening of the eyeball, having found it in eyes which subsequently increased in refraction under his observation before any other indications of this growth were recognizable. Like the retraction of the choroid ring, the detachment of the vitreous body is not limited to M., but can occur during the growth of the axis of the eyeball and the consequent increase of refraction in any eye. Weiss counted this ophthalmoscopic appearance in 69.4 per cent. of M., 32.6 per cent. of E., and 20.6 per cent. of all cases of H., in an examination of 1,094 eyes of school-children. In many of the cases it was very difficult to detect.

Of all the changes found in the M. eye the essential

* This does not preclude that the choroid should be stretched, and accordingly thinned most, in the region where the principal scleral bulging occurs.

† When the myopic bulging involves the posterior pole more than the region of the disk, the papilla may also seem oval on account of being seen in perspective.

one is the yielding of the sclera at the rear of the eyeball, resulting in the elongation of the latter. It has not yet been learned in what the structural or mechanical predisposition consists which permits this distention. The view once defended by v. Graefe, that this is the result of a posterior sclero-choroiditis has been refuted by the microscope. For no indication of a primary inflammatory process can be found—merely atrophic changes. Hasner [23] has claimed that a relative shortness of the orbital part of the optic nerve causes a traction upon the rear of the eyeball during lateral movements which tends to elongate it. Measurements of the length of this nerve in cadavers, by Weiss,[24] seemed to confirm this theory, but since they have not yet been published in full, no opinion can be formed of their value. The greatest bulging, however, of the sclera is generally found at the posterior pole and not at the point of entrance of the ocular nerve through the membranes, which fact constitutes a serious objection to this view.

It has been noted by all oculists that M. runs in families. Although many patients do not know of other cases of short-sightedness among their relations, there are, on the other hand, families of which more members are myopic than could be expected from mere chance distribution of this type of eyes. This is especially true of the higher grades and more malignant forms of short-sightedness. Heredity can hence be considered as an important factor in the causation of M. Attempts have been made to prove this statistically by questioning each individual in collective examinations relative to the state of sight of the parents. Although results have been obtained favoring the assumption of an hereditary influence, statistics beset with so many sources of error can hardly be as conclusive as the ordinary observation in an oculist's practice. The importance of an hereditary influence must not be overrated, because numerous exceptions to it are found daily. There are besides frequent cases in which only one eye is markedly myopic, the other being only very slightly so, or emmetropic, or even hypermetropic. It must be borne in mind that we do not know the nature of hereditary predisposition even where it unquestionably exists.

The formation of the skull may have some influence on the refraction of the eye. Mannhardt[26] claimed that great width of the skull between the eyes predisposes to M. on account of the greater work imposed upon the internal recti muscles during convergence. But this view is not at all sustained by the measurements of the intra-ocular distance by Emmert[27] and Beselin.[28] Bono,[29] however, has shown that a relatively long antero-posterior diameter of the skull (dolichocephaly) is mostly accompanied by greater depth of the orbits, and that this type of skull is more often conducive to M. than brachycephaly, in which the length of the cranium is shorter compared to its width. In the examination of 250 cases (80 M., 100 E., 72 H.) he found the cephalic index (relation of interparietal to antero-posterior diameter) to be in :

	Minimum.	Average.	Maximum.
M.	73	80	87
E.	75	81	89
H.	81	86.5	98

He regards the M. occurring in such long skulls rather as a structural anomaly and not of as malignant a type as the elongation of the eyeball in a brachycephalic head.

While our knowledge of the orginal cause of M. is thus defective, the conditions influencing its progress are perhaps somewhat better understood.

It is universally conceded that the growth of M. is favored by eye-work at short distances, especially during the period of growth of the body. This influence of literary work upon progressive short-sightedness is apparent in the increased number of myopic eyes, in school examinations, on passing from the lower to the higher classes. As previously stated, the average degree of M. is also found greater in the higher school grades. But it can be urged that the average age of the pupils increases from class to class, and that M. progresses with the age of the individual. More conclusive, hence, are the statistics among military recruits, who, in European countries, constitute the representative youth of the population within the ages of eighteen to twenty years. Tscherning's striking results have been described on page 87, together with the statistics obtained by Seggel. Their figures leave no doubt as to the influence of literary education and close eye-work on the distribution of M. They teach forcibly that persistent use of the eyes is one of the most important conditions in the development of M. in any eye predisposed to it. The necessity of a predisposition to M. cannot be denied, for the very statistics which show the influence of eye-work upon the progress of M. show as well that M. develops only in a certain percentage of the eyes subjected to the same strain in schools.

It is not definitely settled which of the processes involved in close eye-work constitute the important factors in the production of short-sightedness. The effort of accommodation was formerly accused as the chief cause of progressive M., especially after it had been shown that contraction of the ciliary muscle pulls the lateral part of the choroid forward. But this movement cannot be made to explain any of the myopic lesions on any mechanical basis. Moreover, it is an every-day experience that M. may pursue its progressive course when not at all or not fully corrected by concave glasses, in which case the accommodation is very little called upon, or even not at all. The spasm of accommodation which Dobrowolsky postulated occurs only as a rare exception, and cannot hence be of influence in the average case. The accommodation theory has been mostly abandoned at the present day, and the dread formerly prevalent, of fully correcting M. by means of concave glasses of sufficient strength, has been shown to be exaggerated if not groundless.

There is more reason to regard the convergence of the eyeballs during close work as one of the conditions conducive to M. If the M. be not corrected, there exists, indeed, a vicious circle. For the nearer the far point moves toward the eye, the greater must be the convergence necessary for the maintenance of binocular vision. Whenever the internal recti muscles rotate the eyes inwardly, the external recti muscles are put on the stretch, and, being wound up on the eyeball by the forward movement of their scleral insertion, they must exert a pressure upon the eye. With the greater length and ovoid shape of the myopic eye, this compression necessarily increases, because the posterior pole of the myopic eye, being farther distant from the centre of rotation than in emmetropia, subjects the external rectus to greater traction while rotating. The compression of the eyeball thus produced and maintained cannot but augment the distention of the sclera. That the insufficiency of the internal recti muscles so common in M. should play any direct rôle in the progression of the complaint has not been shown satisfactorily, in spite of theoretical argumentation by various authors.

Another condition accompanying eye-work is scarcely referred to in the literature, but seems of importance to the writer. In all organs which physiologists have been able to investigate, activity has been found associated with increased blood-supply. In the case of the muscles, the glands, and—perhaps it may be said with some reserve—the brain, a physiological dilatation of the blood-vessels has always been observed during their period of activity. It can scarcely be doubted that this is true of the eye as well, although this hyperæmia has not been demonstrated. It is well known that the intra-ocular pressure depends upon the blood-pressure in the ocular vessels. There is hence every reason to expect an elevation of intra-ocular pressure during eye-work. However, we possess no means as yet of measuring the tension of the eyeball in man with sufficient accuracy to settle this point. Although a morbid rise of tension is not a part of typical M., it is but logical to grant that the yielding of the sclerotic wall will increase, the greater the steady pressure brought to bear upon it.

Donders has also called attention to the danger to which the myopic eye is subjected whenever the flow of blood through the veins is impeded by a stooping position or by constricting apparel around the neck. The propriety

of this caution is universally admitted, though an absolute demonstration of the danger is still wanting.

Any circumstances which render the eye-work more arduous, such as insufficient illumination, small or blurred print, and dinginess of the paper, increase the tax upon the eyes. By enforcing greater convergence in order to see under a larger visual angle, and perhaps, also, by augmenting the blood-supply to the eye, these conditions cannot but exert an unfavorable influence upon the course of M. If insufficiency of the internal recti muscles plays any rôle in the production of M., it probably acts, too, by favoring congestion by reason of the greater strain.

Tscherning has pointed out that very high degrees of M., above 9 D., occur as often among the illiterate as among the more educated classes. The same fact has been noted by Seggel. It seems likely, therefore, that this excessive short-sightedness, which is fortunately rare, represents a morbid condition of such progressive tendency that it requires no favorable conditions like close eye-work for its development.

Myopia has been observed in rare instances as a consequence of acute enfeebling diseases, following in such cases a rapid course. Some of these instances, however, amount merely to spasm of the accommodation without anatomical change in the eyeball. In other cases the M. following some acute disease proves to be astigmatism, perhaps with a slight degree of M. which had formerly escaped the patient's notice, on account of partial correction by action of the ciliary muscle.*

It is possible that there may exist a form of M. due to an increase in the index of refraction of the lens, since the beginning of cataract is occasionally announced to the patient by an increase of refraction.

Secondary Morbid Changes in Myopic Eyes.—It has been emphasized repeatedly that high degrees of M.

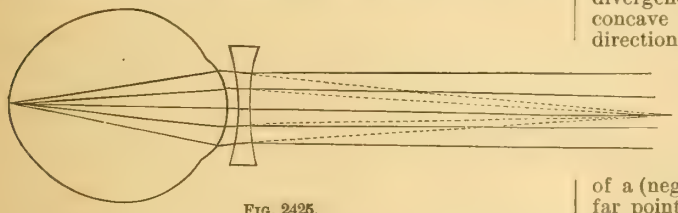

Fig. 2425.

lead almost invariably to secondary diseases which impair the utility of, if they do not ruin, the eye. A myopia of over 9 D. will seldom leave an eye intact during advanced age, and, indeed, whenever the short-sightedness exceeds 6 or 7 D. and has been progressive, such disastrous results may follow. The first and most common of these complicating diseases is the reduction of visual acuity, without ophthalmoscopic change. This diminished sensibility of the retina is to be regarded as a secondary complication of M., because it does not occur invariably, at least in the lower degrees of M., and because it may vary in extent in different eyes of the same refraction. Its frequency and actual degree have been described in the section on symptomatology. It has not yet been demonstrated what changes; if any, in the retina cause this reduction of sight.

The fundus of highly myopic eyes presents frequently white patches similar to the crescent, but distinct from it in location, being scattered throughout the bulging part of the rear of the eyeball. They are evidently the result of an exposure of the sclera by reason of atrophy of the choroid and disappearance of the retinal pigment. Although plainly covered by the retinal tissue, they are generally not sensitive to light, presumably from loss of the layer of rods and cones. The visual field is in consequence defective in spots—circumscribed *scotomata*. These patches are the result of the atrophic process occurring in the choroid throughout the staphylomatous region.

White spots, somewhat similar in appearance but surrounded by pigment rings and often enclosing hæmorrhages, may also occur as the result of inflammatory action. Choroiditis, with or without such secondary atrophy, produces also changes in the vitreous body in the form of membranous or other circumscribed opacities, which are sometimes pigmented. The vitreous body is rarely normal in high degrees of M., being often detached from the retina and partly or wholly fluid, which consistency increases the danger of cataract operations in M. As a final result of insidious choroiditis and changes in the vitreous of the myopic eye, retinal detachment may occur. This is perhaps the greatest danger threatening the myopic eye. The inflammation of the choroid tissue may also lead to nutritive disturbances in other parts. There may occur in such eyes a form of cataract of the posterior pole of the lens rather characteristic of malignant myopia. Plastic inflammation of the iris can also complicate the sad combination of choroiditis and retinal detachment.

In many instances of malignant myopia central vision becomes entirely abolished, while the sight of the periphery of the retina may yet be serviceable. This is sometimes due to retinal hæmorrhages in the region of the fovea centralis; in other cases it is the result of a central choroidoretinitis.

As regards the frequency of secondary diseases in M., no definite figures can be quoted. Among 1,000 blind eyes, Seidelman[30] counted 46 with central retinitis due to M., and 46 with retinal detachment as the result of M., a total of 9.2 per cent. of eyes lost by malignant myopia.

Treatment.—*Correction by Glasses.*—The myopic eye cannot reunite any rays in the plane of its retina which are less divergent than those coming from its far point. In order to obtain sharp images of distant objects the divergence of their rays must hence be increased by concave glasses. Fig. 2425 illustrates the change of direction which parallel rays coming from a distance undergo on passing through a concave glass in front of the eye. The glass which fully corrects the M. gives the rays a divergence as if they emerged from the far point of that eye. The glass required for the formation of perfect retinal images of distant objects in M. must be of a (negative) focal length equal to the distance of the far point from the anterior principal point in the eye. Such a lens would correct the M. perfectly in theory, if its first principal point coincided with that of the eye, that is to say, if it were placed practically in the anterior chamber. If the glass is held in front of the eye, its action diminishes as the distance between the glass and the cornea increases, according to the formula:

$$\frac{1}{M} = \frac{1}{f-d}$$

wherein M is the distance of the far point; f the focal length of the glass; and d the distance between glass and cornea (more accurately between the first principal point of the glass and the first principal point of the eye). (Compare article on Accommodation and Refraction.)

This calculation can be more easily made by designating the M. and the glasses according to the old method of fractions than in the "dioptric" notation. In the case of M., or the correcting-glass weaker than $\frac{1}{6}$, the effect of the distance from the eye is too slight to be taken into account practically, but in selecting stronger glasses it is well to make allowance for the distance at which the glass must be held, on account of the bridge of the nose. Thus M. of $\frac{1}{3}$ is corrected by a glass of $\frac{1}{2\frac{1}{2}}$ at a distance of $\frac{1}{2}$ inch, but if the spectacles cannot be approached nearer than $\frac{3}{4}$ of an inch, a glass of $2\frac{1}{4}$ inches focal length is required, the difference between the two being equal to a lens $\frac{2}{4\frac{1}{2}}$.

Concave glasses diminish the size of retinal images by reason of their influence upon the nodal points of the eye, principally the posterior nodal point. With a given distance of objects the size of the retinal image depends

* This statement is based upon some observations of my own.

on the distance between the posterior nodal point and the retina, which length increases in axial M. with the elongation of the eyeball. The posterior nodal point moves back when a concave glass is held in front of the eye. If this correcting glass be between the eye and its anterior focus ($F_1 = 15.5$ mm.), the distance between posterior nodal point and retina is still greater than in the emmetropic eye, and the retinal images are hence larger than in E. If the glass be situated in the anterior focus of the eye, the retinal images are of the same size as in E.; while if the glass be moved beyond the anterior focus the posterior nodal point approaches the retina closer than in E., and the myopic eye obtains now smaller images than the emmetropic eye. It is hence advisable to wear the spectacles as close to the eyes as possible, in order to diminish the size of the retinal images as little as possible.

On account of the recession of the posterior nodal point the visual field is slightly enlarged by concave glasses. The anterior nodal point is moved forward by concave glasses only when they are held in front of the anterior focus of the eye, while, when nearer to the eye than this distance, the glass causes the anterior nodal point to recede slightly. On the position of the anterior nodal point depends the visual angle under which objects are seen. But since concave glasses, at the distance from the eye at which they are ordinarily worn, do not move the anterior nodal point forward appreciably, if at all—their diminishing influence upon the apparent size of objects, as seen through them, cannot be referred to a change in the visual angle.

On looking slantingly through a concave glass it acts no longer as a strictly spherical lens, but exerts in addition an action of a cylindrical glass. The distortion of images thus produced is slightly less in the case of *periscopic* or concavo-convex glasses than in the case of biconcave lenses. Such concavo-convex spectacles do not diminish the apparent size of objects quite as much as biconcave lenses, at least if they are of any considerable thickness.

Concave glasses enlarge the range of accommodation, but practically this influence is too slight to be taken into account.

If spectacles are not correctly centred, that is to say, if the thinnest part of a concave glass is not exactly in front of the centre of the cornea, they act as prisms. If the two glasses are too near together they represent prisms with the bases outward, and apparently displace objects inwardly with reference to each eye, thereby increasing the tax upon the convergence, which in M. is so often enfeebled. On the other hand, too great a width of the spectacle-frame, causing the glasses to act as prisms with their bases inward, is less objectionable, and, indeed, sometimes advisable.

In order to decide what glass should be worn by a myope, the degree of M. is to be ascertained in each eye, preferably by a preliminary examination with the ophthalmoscope. According to the skill of the observer, the ophthalmoscopic examination may be made accurately or only approximatively. Besides informing as to any lesions in the eye, the ophthalmoscopic examination will save time in the selection of glasses. It is next to be ascertained which is the weakest concave glass giving each eye the best possible sight, and whether the sight, if not satisfactory, can be raised by the addition of cylindrical glasses. If the results of ophthalmoscopic examination and of functional test do not agree, either astigmatism or overaction of the ciliary muscle must be suspected, and the accommodation should be paralyzed, The most convenient drug for this purpose is homatropine in two per cent solution, which, if dropped into the conjunctival sac a few successive times, paralyzes the ciliary muscle completely in the course of half an hour to one hour. If the ophthalmoscopic examination agrees with the functional test, there is no object in employing homatropine for diagnostic purposes.

Many oculists have hitherto feared to permit their patients the use of fully correcting glasses, under the assumption that accommodative efforts favor the progress of M. For, in uncorrected M. the accommodation is less called upon than in E. This prejudice is not supported by proof. The fact that M. may increase while glasses are worn, does not prove that the glasses are the cause. On the other hand, Foerster [1] has lately reported his experience in a large number of cases of medium and high degrees of M., in which fully correcting glasses had been worn for many years without any increase of refraction. Many of his patients had even made use of spectacles stronger than their degree of M. without injury. While the report of such isolated cases not injured by the use of fully correcting glasses, especially after the period of growth had been passed, would not be a convincing argument, no one has yet quoted any similar number of cases of which it could be shown with certainty that their M. had been increased by these means. My own experience agrees fully with that of Foerster.

While fully correcting glasses may be permitted by the oculist, they need not be urged in all cases if other objections arise. The safest rules are the following: Select the glasses which give the greatest comfort, enable the patient to work at a distance of at least fifteen inches, and give the best sight under these conditions. When the M. is not over 2.5 D. the patient can be allowed to choose for himself, whether he wishes glasses or not, and whether he is to wear them for close work. Glasses of more than perhaps 2 D. are apt to fatigue the eyes if worn only part of the time and not steadily, for the reason that their use changes the established association between convergence and accommodation. If they be worn continuously these two functions soon become accustomed to a new association. In M. of 3 D., or more, the far point is at such a short distance from the eye that the power of convergence is unduly taxed during eye work. Such patients should, therefore, use for work a glass enabling them to see distinctly at fifteen to eighteen inches distance. Such a degree of M. also makes the use of correcting glasses for the distance very desirable, on account of the otherwise very indistinct sight. Whether the glasses worn in this degree of M. correct the refraction fully, or leave a balance of 0.5 to 1 D. of M. uncorrected, may be left to the patient. Not rarely patients refuse utterly, even for the far distance, the glass which neutralizes their M. accurately, on account of a feeling of strain which it gives them. The cause of this discomfort is not quite clear. Persons who demand sharp sight for the distance will generally become accustomed to their glasses and lose the feeling of discomfort in the course of a week. If they desire it they may take weaker glasses temporarily, and, as they become habituated to them, increase the strength gradually up to full neutralization of their M. In some instances the relaxation of the ciliary muscle, by means of one application of homatropine, enables them at once to accept full correction without discomfort. When the power of accommodation is enfeebled by exhausting diseases or age, the glasses used for work must be so chosen that no accommodative strain occurs. We may calculate the strength of the glass required by determining the convex glass which an emmetrope of the same accommodative power would require for work, and deducting this from the number of the fully correcting glass. Thus a myope of 4 D., at an age of over fifty years, and an accommodative power of perhaps 1.5 to 2 D. at the utmost, would require concave spectacles of eighteen-inch focus (—2 D.) in order to work with comfort at eighteen inches distance. Similar rules apply if the myope has imperfect control of his accommodation, by reason of having worked up to the time of consultation without glasses. In this case, however, gradual use will finally give the myope full control of the accommodation proper to him by reason of his age. If the patient, for one or the other reason, prefers to wear the partly correcting spectacles continuously, he may improve his sight for the distance by raising, when required, an additional eye-glass which fully neutralizes the balance of his M.

In high degrees of M. with reduced acuity of sight, fully correcting glasses are not agreeable on account of the diminution in size of the retinal images. When the

retinal sensitiveness has suffered, the patient prefers, as a rule, large blurred images to sharp outlines with diminished size. In such cases we must be guided in the selection of glasses for the distance by the patient's own choice. Some little enlargement is gained by using periscopic (concavo-convex) glasses, but while their advantage increases with their thickness, a limit is set by reason of their weight. Some of these unfortunates are willing to make use of a small telescope or opera-glass for glimpses at distant objects. A still greater dilemma arises as to their sight for work. When the M. is still progressive, as shown by their past history, and when there are evidences of choroidal inflammation, it is best to forbid all eye work. If the patient cannot submit to this rule, or if the M. has not been progressive for some years, various means may be tried to enable him to work with some comfort. On account of the convergence, it is always best to give a glass of such strength as to move the far point to a distance of at least fifteen inches, selecting the weakest glass which will accomplish this. But when the sight has been much impaired it is simply not possible to read or sew at such a distance, and the objects must be held nearer in order to be seen under a larger visual angle. Some of these patients learn to read by the use of partly correcting concave glasses, while a large reading glass of some two inches width and four to six inches focal length is held over the print. This combination acts as a magnifying telescope. Other persons may be accommodated by wearing fully correcting (or nearly so) concave spectacles, and adjusting besides a convex eyeglass of 2 to 3 D., with as large a distance between the two pairs of glasses as the shape of the nose permits. This combination acts likewise as a magnifying telescope, but of less power than the previous arrangement. Donders has suggested partly correcting glasses, surrounded in front by a metallic shell with a horizontal slit, which, by diminishing the aperture through which the light enters, improves the definition of the images. But this *stenopæic* slit limits the field of vision to such an extent that it can rarely be employed with advantage. The largest images are, of course, obtained, in very high degrees of M. (15 to 20 D.), by reading at the far point, which almost touches the nose, without any glasses. In such extreme cases there is seldom any binocular vision, but almost always divergent squint. This anomaly of the external muscles diminishes the strain upon the internal recti muscles considerably, but does not obviate it wholly. For even in this case, the approach of any object toward the one eye is accompanied by corresponding rotation of the other toward the median line. The patients should hence be warned that, even under these circumstances, there is danger in such use of the eyes if the M. be still progressive.

In M. complicated with astigmatism, it is difficult to determine the refraction accurately, on account of the frequent over-action of the ciliary muscle—and it is generally safest to employ homatropine in persons under thirty-five or forty years of age. Whether cylinders should be added to the concave glasses depends on the previous existence of asthenopic symptoms referable to the astigmatism, and on the amount of comfort and improved sight which the trial glasses give the patient. Astigmatism of not more than 0.5 D., or less in amount than one-fourth the degree of M. present, can generally be neglected.

When the refraction is unequal in the two eyes, that is to say, in cases of *anisometropia*, no one rule can be followed. If the patient wishes to wear glasses steadily, or the degree of his M. renders this imperative, it is best to correct each eye absolutely. If necessary, temporary paralysis of the accommodation may make these glasses acceptable. If the spectacles are not to be worn steadily, or if the more myopic eye is much inferior to the other, it is generally most comfortable to fit both eyes with the glass needed by the less myopic one. If one eye be emmetropic or nearly so, it must be decided by means of the trial glasses whether the patient is most comfortable with correcting glass for the myopic eye, and plane glass (or whatever weak number he may need) for the other, or without any spectacles at all.

Hygienic Management of Myopia.—Short-sightedness of unmistakable stationary character requires no more care than the emmetropic eye. But during the period of growth of the body, it is often difficult to decide whether the M. is at a definite standstill or not. The more evident, however, the tendency to increase of M., the stricter should be our directions as to the limitation of eye strain, and in unmistakably malignant cases, it is certainly the safest plan to avoid all eye work. Under any circumstances, the patient should be fitted with glasses enabling him to work at a distance of fifteen to eighteen inches, and in order to reduce the convergence as much as possible, a shorter working distance should not be permitted during the earlier part of life. If a child will approach his work in spite of orders, some mechanical device must be employed to maintain a distance of some sixteen inches between book and eye. In the European markets there exist various forms of head and chin supports for this purpose, of which Kallman's seems to be the best. This consists of an upright pillar clamped to the edge of the table, with a ring attached above of such size as to surround the face. The forehead, resting against the upper part of this ring, is thus prevented from approaching the book nearer than the desired distance. In the American markets I have not found any of these simple devices. But it is easy to attach a rod to the table, against which the chin is to rest; or still simpler, to let the patient hold between his teeth a fifteen-inch ruler, which prevents him from approaching the book. Foerster has reduced the effort of convergence still further, in some of his cases of progressive M., by combining with the concave glasses prisms with the bases inward up to an angle of five or even seven degrees for each eye. Such glasses are annoying, by reason of their weight and the slight distortion of images, but still the results of Foerster in arresting the progress of M. would warrant further trial.

The easiest position in reading or writing is attained by having the table project over the edge of the seat, so as to avoid stooping forward. The top of the table should slant in order to obtain a full view of the letters, and not see them foreshortened in perspective, as they appear on a level table. This arrangement, besides, insures the best illumination, if the source of light be, as it should be, behind, above, and somewhat laterally from the body. The light should be strong enough, under all circumstances, to give a normal visual acuity when test-types placed on the table in question are seen from the prescribed distance. For in insufficient light the tendency to bring objects closer, and thereby increase the visual angle (and the convergence), is irresistible. Any artificial light should give a steady—not flickering—flame, and not be placed so as to strike the eye directly, thereby fatiguing the retina and irritating the conjunctiva by radiant heat. The print should be of sufficient size to be plainly legible. Cohn,[9] on summing up the investigations of different authors, demands as the minimum size a height of 1.5 mm. for the smallest letters; a thickness of ¼ mm. of the strokes; a distance of 2½ mm. between the lines; a width of column not exceeding 100 mm., and containing not over 60 letters per line. Any smaller size than these measures is to be regarded as injurious, and the more so the younger the individual. The paper should be sufficiently clean and bright in order to form a due contrast with the print. These conditions are fulfilled in the majority of American school-books, but by no means in all works of fiction, especially the cheaper editions. Hence precautions against the abuse of children's eyes must include home reading as well as school-work. Indeed, the medical adviser must bear in mind that teachers are more apt to pay attention to the position of pupils and the conditions of work than most parents. The total amount of eye work done is also to be considered, and is to be limited in proportion to the progressive nature of the individual's short-sightedness.

Curative Measures in Myopia.—An elongated myopic eyeball cannot be restored to its normal state by any means known at present. Steady pressure by means of a pressure bandage or heavy bags has been suggested, but has not given any results encouraging the further

trial of a method of questionable safety. The removal of the lens has also been proposed by adventurous minds. But this operation, certainly dangerous in the case of a normal lens, would only correct the refraction if the degree of M. happened to be the same as the dioptric strength of the lens and it would do this at the sacrifice of the power of accommodation, without checking further bulging of the sclera. The apparent degree of M. can be reduced, in cases of over-action of the ciliary muscle, by the use of homatropine or atropine, repeated if necessary for a few days after giving the correct glasses. In some instances the action of such paralyzing drugs may also be employed advantageously in order to diminish the refraction permanently, by lowering the tonus of the ciliary muscle, whenever this tonus exceeds the average degree. In such cases the mydriatic solution must be used for some days in succession in order to have a permanent effect.

When the visual acuity has diminished rapidly it can often be restored by enforcing absolute rest of the eyes with avoidance of exposure to strong light for a period of one or several weeks. This restoration of visual acuity is hastened by the use of atropine, even when no ciliary over-activity or spasm exists. It is well to shade the eyes during the use of atropine, by means of dark-gray or blue glasses. Formerly leeches or cupping on the temples were in vogue as a part of this cure, but their effect is no more decisive in this case than the effect of local bloodletting in general.

The asthenopic complaints due to increase of M. can be combatted successfully by the same general plan of treatment, viz., rest of the eyes—relative or absolute—and if insufficient, medicinal paralysis of the ciliary muscle with the use of dark glasses. In cases where the asthenopia is not sufficient to prevent business employment, I have seen favorable results from the use of homatropine during the night. A one or one-half per cent. solution of this drug, applied at bed-time, exerts its calming effect upon the eye during sleep without interfering with work in the morning. This method will generally remove the less severe forms of asthenopia due to progressive M., without compelling the patient to desist from his work, provided he limits the eye strain by hygienic measures and avoidance of all dispensable eye work.

Asthenopia due to insufficiency of the internal recti muscles requires comparative rest, and limitation of the strain by holding the work off as far as possible. Prisms with their bases inward are the remedy indicated by theory, but their practical action is insufficient in any but the lowest degrees of this defect. If the concave glasses are above medium strength, some effect may be obtained by decentring them toward the temples. Since such an order is not likely to be well fulfilled by the manufacturing optician, it is better to direct a frame wider by a few millimetres than the interocular distance. High degrees of muscular insufficiency cannot be corrected except by surgical measures, viz., tenotomy of one or both external recti muscles, combined, if necessary, with advancement of the internal recti. Tenotomy of the external recti muscles is admissible only in cases of insufficiency of their antagonists, if there is a certain amount of the power of divergence at the disposal of the patient. This can be tested by determining the least angle of the prism which when held with its basis inwardly causes diplopia. Further directions as regards this operation should be looked for in the article on Strabismus. Tenotomy of the external recti muscles has also been tried to some extent as a preventive measure against the progress of M., under the belief that insufficiency of the internal recti is one of the causes of increasing myopia. No results, however, have been published of such decisive nature as to encourage further trial of this operation, except for the treatment of the muscular insufficiency. Iridectomy and sclerotomy have been proposed by Dransart[32] as methods to check the growth of M. Although his communication is not strictly convincing, these relatively safe operations deserve some cautious trial in cases where rapid increase of M. and steady reduction of sight baffle all other means of treatment.

Historical Bibliography.—Myopia was known to the Greeks, since a description of its effects is found in Aristoteles.

Pliny mentions that there exist certain concave emeralds, and that the short-sighted emperor Nero watched the gladiators' combats through one of this kind. Spectacles were introduced in the earlier part of the fourteenth century, though their inventor has not been traced with certainty. Their optic action was not understood, however, until Kepler investigated the mechanism of the eye, in the beginning of the seventeenth century. Subsequent to this time, myopia and its correction by glasses are mentioned by the writers on eye diseases without further addition to our knowledge. The posterior staphyloma was discovered by Scarpa in 1801, but not connected by him with the myopic refraction. Arlt was the first to trace myopia to elongation of the eyeball (1854). The anatomy of the myopic eye was described by Jaeger in his really magnificent work, "Ueber die Einstellungen des dioptrischen Apparates im menschligen Auge" (Wien, 1861), with a minuteness to which but little has been added by his successors. Jaeger was also the first to make collective examinations of eyes with reference to the refraction. Independent of him, Donders pursued his pathological studies, and published them in his great work on "Anomalies of Accommodation and Refraction" (Sydenham edition, 1864). His anatomical results agree closely with those of Jaeger. He investigated besides the optic structure of the myopic eye, and furnished in this book the most exhaustive clinical study of myopia up to that time, and, indeed, but little has been added to the scope of the subject since Donders work, although an immense literature has been devoted to all aspects of this anomaly. Statistics of refraction of school-children were reported for the first time on any extended scale by H. Cohn, in "Untersuchungen der Augen von 10,060 Schulkindern" (Leipzig, 1867). The immense literature and investigations in the further pursuance of this subject can be found, up to 1882, in Cohn's article on the eyes of school-children (Schulkinderaugen) in "Eulenburg's Real-Encyclopädie d. ges. Heilkunde," and in a shorter *résumé* up to 1885 in an article, by Randall, on "The Refraction of the Human Eye," in the *American Journal of the Medical Sciences* (July, 1885). Of exhaustive monographs on myopia may be mentioned Mauthner's "Vorlesungen über die optischen Fehler des Auges" (Wien, 1872 and 1875), and Landolt's treatise in the third volume of De Wecker and Landolt's "Traité complet d'Ophthalmologie" (Paris, 1885), of which latter an excellent English translation has just appeared under the title "Accommodation and Refraction" (by Culver, Philadelphia, 1886). Landolt's work contains also the most satisfactory discussion of insufficiency of the internal recti muscles, based largely on his own researches. The mathematical problems relating to the subject are fully discussed by Nagel in Graefe and Saemisch's "Handbuch d. ges. Augenheilkunde," vol. vi. The questions of the influence of type upon eyesight have been closely investigated by Javal (in the "Annales d'Oculistique," 1878 and 1879). The most important recent contribution to the treatment of M. by glasses and relaxation of the convergence is the article of Foerster quoted in the text. *H. Gradle.*

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MYOTICS is the name of a class of drugs which contract the pupil and stimulate the muscle of accommodation.

Eserine or *physostigmine*, the alkaloid of the calabar bean, is the most powerful of myotics. Used in the form of a one-half to two per cent. solution of the sulphate, it contracts the pupil to the size of a pin-hole in about half an hour; the pupil now remains stationary for about two hours, and returns to the normal state in the course of from twelve to thirty-six hours. The pupil may be slightly irregular in outline during this time, and never ceases to respond faintly and sluggishly to light. The ciliary muscle contracts within the first half-hour, so as to cause the far point to approach the eye, and this apparent increase of refractive power, or—what it really amounts to—this spasm of accommodation lasts, according to the strength of the solution, up to twenty-four or thirty-six hours. The range of accommodation is increased by reason of the greater control of the will over the calabarized muscle, so that the eye can be adjusted for shorter distances than normally. The muscular contraction is accompanied by more or less pain and dull ache. The narrow pupil darkens the sight somewhat, but the retinal images of objects situated within the range of accommodation are very sharp. On account of the abnormally facilitated response of the ciliary muscle to the will, the judgment is misled into believing objects to be larger than they really are. Eserine decomposes gradually when in solution, forming the inactive, red rubreserine.

The effect of eserine is due to its stimulating influence upon the nerve terminations in the ciliary muscle and in the sphincter of the iris. Any agent, like atropine or its substitutes, which paralyzes these parts, overcomes the action of eserine. There exists, however, a mutual antagonism between myotics and mydriatics in their action upon the pupil. The contraction due to eserine can be overcome by any of the mydriatics (except cocaine), and it is only a question of quantity or repetition of the mydriatic in order to paralyze the iris and ciliary muscle completely, in spite of eserine. On the other hand, during maximal mydriasis eserine will still exert a slight transient effect, if used vigorously; and in the case of the more transient action of the substitutes of atropine, like homatropine or duboisine, eserine may be pushed by repetition so as to obviate the mydriatic paralysis.

The intra-ocular pressure is distinctly lowered by eserine.

Pilocarpine exerts an effect upon the iris and upon accommodation and tension of the eye, similar to that of eserine, but feebler in degree and more transient. Accordingly its action is not quite as painful as that of the other myotic.

Therapeutic Use of Myotics.—In cases of paralysis of the sphincter muscle of the iris or of the muscle of accommodation, the recovery, if at all possible, is hastened by stimulation of the nerve-ends by myotic solutions. If the corresponding nerves are, however, affected beyond the possibility of recovery, which time only will reveal, no myotic is of any service.

An important use of myotics may be made in glaucoma. During an acute attack these agents, especially the more active eserine, will lower the intra-ocular pressure and mitigate the attack, or even abort it. This action is more marked the more acute the attack, but is not absolutely reliable by any means. The myotic may be used in order to postpone the curative operation, iridectomy or sclerotomy, or to facilitate it by contracting the pupil and deepening the anterior chamber; but it should not be employed in the hope of obviating the operation. In the chronic forms of glaucoma myotics are of less service. Yet it has been claimed that, in those chronic cases where iridectomy sometimes fails, a cure can be obtained by the continued use of pilocarpine. The greatest benefit is derived during the prodromic stage of glaucoma, by directing patients to use a one or two per cent. solution whenever there are any indications of impending attacks, and thereby postponing operative measures sometimes for a long period. The influence of myotics on the intra-ocular pressure is of service in ulcers of the cornea, the floor of which bulges outward, threatening to become staphylomatous. In operations or wounds of the periphery of the cornea the use of eserine during the time of closure of the wound may prevent entanglement of the iris in the cicatrix.

The most complete *résumé* of the action of myotics can be found in Landolt's "Accommodation and Refraction." Further details must be sought for in the periodical ophthalmic literature, according to references in the larger text-books on Eye Diseases. *H. Gradle.*

MYRRH (*Myrrha*, U. S. Ph., Br. Ph., Ph. G.; *Myrrhe*, Codex Med.). A gum resin, probably obtained from *Balsamodendron* (*Balsamea*) *Myrrha*, Nees von Essenbeck. Order Busseraceæ: A not well-known, spiny shrub, with coarse, crooked branches, and sparsely scattered clusters of few trifoliate leaves, of which the central lobe is developed into a wedge-shaped blade about half an inch long and the two lateral ones are mere rudiments; flowers not known. The tree is a native of Arabia where most of the drug is obtained. *B. meccanense* is also reputed to yield the same product. Our knowledge of the collection of myrrh is also imperfect, but it is said that it exudes spontaneously from the branches, and is simply gathered when dry, as gum Arabic and other similar "gums" are, and afterward sorted into various grades Few articles have been known as long as this, which has been a component of incense or used in some way in religious ceremonies for thousands of years. Its medical employment is also of great antiquity.

Myrrh consists of rather irregular lumps or tears of varying size, from that of a hen's egg down, but generally not larger than good-sized beans, of a dull reddish or brown color, without much lustre, and a rough, waxy fracture. Its odor is peculiar and agreeable, its taste bitter, its texture hard and moderately brittle; the gum in it prevents its melting completely; its oil makes pulverization difficult.

Composition. — A small amount (three-fourths per cent., Flückiger; two to four per cent., Husemann) of *essential oil*, a *bitter principle* not fully separated, from twenty-five to thirty or more per cent. of *resin*, soluble in chloroform and alcohol, and from forty to fifty or more per cent. of *gum*, besides mechanical and coarse impurities.

Action and Use.—The use of myrrh as an emmenagogue appears to be one of tradition rather than founded on evident value; it is probably no better in this respect than numerous other resins and terebinthinate oils, which are occasionally employed. Still some of the compound pills containing myrrh are used with reference to this property. As a mild, aromatic stimulant it is properly added sometimes to cathartic pills. It is occasionally used as an expectorant. Myrrh is very seldom given alone or as a principal medicament internally. Externally it is used as a mild astringent, and is often employed in washes and gargles. The tincture diluted with water, in the proportion of one to three or four, makes an excellent surgical application for moderately indolent surfaces,

and still more diluted, a good and agreeable mouth wash. The following preparations are officinal: The tincture (*Tinctura Myrrhæ*, U. S. Ph., strength $\frac{1}{10}$), Tincture of Aloes and Myrrh (*Tinctura Aloes et Myrrhæ*), $\frac{1}{10}$ of each, alcohol $\frac{1}{2}$. Pills of Aloes and Myrrh (*Pilulæ Aloes et Myrrhæ*), with two grains of Aloes, one of Myrrh, and half a grain of Aromatic Powder in each; Compound Pills of Iron (*Pilulæ Ferri Compositæ*), with a grain and a half of Myrrh, and three-fourths of a grain each of Sulphate of Iron and Carbonate of Sodium in each; and Compound Pills of Galbanum, Galbanum and Myrrh each a grain and a half, and Asafœtida half a grain in each. In all these preparations, excepting the first, the Myrrh takes only a subordinate place.

Allied Plants.—The genus *Balsamea* or *Balsamodendron* consists of half a dozen African and Arabian shrubs, with thorny branches, generally trifoliate, small, often fascicled leaves, and minute polygamous tetramerous flowers. Several species, besides the above, are sources of commercial products: *B. meccanense* Gleditsch (*B. opobalsamum*) yields the formerly prized Opobalsam or Balm of Gilead,* now obsolete. *B. mukul* Hook., the East Indian balsam, Bdellium, also out of use, at least here; *B. africanum* Arnott, of Senegambia, supplies a Bdellium from that region, and there may be others. The order comprises one or two hundred tropical shrubs and trees of resinous and aromatic or balsamic properties: *Boswellia Carterii* Birdwood, and one or two other species yield Olibanum. *Canarium commune* Linn. is the origin of Manilla Elenii, and the genera *Icica* and *Bursera* also produce resins or balsams of former repute.

Allied Drugs.—Myrrh is a type of a considerable number of natural mixtures of resin of some sort, with gum or mucilage, and almost always a little essential oil. They are generally contained in the laticiferous vessels of the plants that yield them, and before exudation and desiccation they appear as white or colored opaque liquids; rubbed with water they again assume a similar condition and make more or less complete emulsions, the resins held in suspension by the mucilage. Besides the products mentioned in the preceding paragraph, the following gum resins may be compared with myrrh, although their medicinal properties vary considerably: Asafœtida, Galbanum, Gamboge. Therapeutically Myrrh can claim no important peculiarities to separate it from a number of mild resins used in plasters or as stimulating additions to laxative pills. See Turpentine. *W. P. Bolles.*

MYXŒDEMA. Cachexie pachydermateuse. "A cretinoid state supervening in adult life in women" (Gull).

A peculiar disease of adult life attended by a mucoid deposit which invades the skin as well as various internal organs, and characterized by changes in the thyroid gland, diminished temperature, and various derangements of the sympathetic nervous system. The disease was discovered by Sir William Gull, and has, since his early communication, been more extensively described by Hadden and Ballot, Fox, and others abroad, and by Ball, Cushier, Hammond, Holland, and myself in this country. While the number of cases so far reported is less than one hundred, I am of the opinion that it is far more common than we imagine, and doubtless many cases of supposed renal disease, of an obscure kind, are of the nature of myxœdema. The victims are for the most part women, and the proportion is almost one to ten. I have seen six cases, and one of these was a man. The other American cases were all women. There seem to have been more male cases in France than elsewhere. The female subjects are usually those who have passed the menopause, and have undergone more than ordinary taxation of the reproductive organs. Many women have borne six or more children, and have had miscarriages, and some have suffered from repeated and profuse uterine hæmorrhages. I have been unable, in any of my cases, to find any hereditary or other causes, though in the case of an Italian who had come from the base of the Apennines, I was inclined to suspect some climatic influence. The disease is usually unrecognized for a long time—commonly not until some distinct objective signs have made their appearance. The early subjective disturbances are loss of appetite, great susceptibility to cold, fatigue upon slight exertion, palpitation, and some mental depression. Sensory symptoms are paræsthesia, or neuralgia. When the disease becomes established—which may be after the prolonged existence of the above early symptoms, the patient becomes conspicuous by reason of a peculiar swelling of the whole body, but especially the face. This swelling is hard, doughy, and involves the cheeks and forehead, the eyelids, lips, and tongue. The nose becomes broad, and the wrinkles, if there be any, are obliterated. The eyebrows become arched as a result of the tension of the skin; there are puffy swellings beneath the eyes, which vary in degree from day to day. The tongue when protruded is often found to be enormously swollen, so that articulation is interfered with and speech becomes thickened. The vocal cords are swollen and infiltrated and do not approximate. The lips, in point of size, are like those of a negress, but are blue and shiny. The mouth becomes dry, and whatever saliva that may collect is tenacious and gluey. The patient is clumsy in all his movements and progresses with great difficulty. The ordinary use of the fingers in sewing, writing, or buttoning clothing is greatly interfered with. There is rarely pitting upon pressure, though this may sometimes occur. Even when there is great swelling of the tissues the urine rarely contains albumen, and never any evidence of epithelial exfoliation. All the tissues feel boggy, and the skin is shiny and like morocco. Its color is like old wax or parchment, while it is not uncommon to find two spots of bright redness over the malar eminences. The finger-ends are swollen, and a clubbed appearance is present. Hearing is dulled, and there is a slowness of perception, which does not always depend upon an actual defect in the auditory apparatus, but is rather due to cerebral difficulty. It takes such patients a long time to accept a suggestion or respond properly. Late in the disease there is a condition akin to dementia—loss of memory, fanciful ideas, which may amount to delusions, and sometimes resulting in suicidal attempt. Arterial tension is increased, and the circulatory apparatus is evidently subject to mechanical embarrassment. Unilateral lowering of temperature is common. I have found a difference of over a degree upon the two sides, without any seeming preponderance of mucoid deposit. The fundus oculi presents a peculiar tumefied appearance, and choked disk is occasionally found. The hair undergoes remarkable changes, and usually loses its pigment and becomes thin and brittle. This is especially noticeable at the top of the head, but occasionally very remarkable alterations are found elsewhere. Sometimes there is a new deposit of pigment. In one aged individual whose hair was white, I was surprised to find a dense crop of thick black hair intermingling with the white. The skin becomes the seat of dark morphœa-like patches, and an interesting comparison may be drawn between the color deposition in these cases and that which occurs as an accompaniment of pregnancy. The speech becomes slow and drawling, or actually ataxic, from the enlargement of the tongue, and the hearing in one or both ears is diminished.

The last stages of the disease are characterized by increasing weakness and helplessness, and finally death. The duration of the malady is variable, but it is always a slow and progressive affection, and I have known it to extend over a period of ten or twelve years.

So far as the pathology of myxœdema is concerned nothing has been absolutely determined. My own idea is, that it is a disorder of the sympathetic nervous system, and is really a manifestation of type retrogression, taking its place with certain varieties of carcinoma. The fact that cretinism is but myxœdema of a different variety (and the hereditary genesis of this form of idiocy is well established) leads me to suppose that it is but a type-reversion. Cretinism, atavism, and certain forms of chronic insanity of late development, in which thyroidal

* That which is sold in this country now as Balm of Gilead is quite another product, *i.e.*, the buds of *Populus balsamifera* Linn.

and trophic changes play a part, form a suggestive group, in which myxœdema takes a place. A number of experiments have been undertaken by Horsley and others, which have demonstrated that destruction or removal of the thyroid was followed by myxœdematous changes. These are undeniable, but whether the absence of this organ, or irritation of certain cervical sympathetic fibres, is the cause, has not been determined. Billroth has performed thyrodectomy quite frequently without any secondary results. Hadden and others have inclined to the bulbar origin of myxœdema, but my experience, which is by no means inconsiderable, makes me believe that the invasion of the medulla oblongata is but secondary.

There is little danger of confusing this affection with any other, except it be some renal disorder; but in the former the urine is, as I have said, usually free from evidence of structural nephritic disease, and the swelling is boggy, and does not pit under pressure in the manner peculiar to œdema.

As to treatment, little or nothing can be done. Perhaps the use of digitalis or nitro-glycerine does some good in altering the arterial tension, but no remedy is actually curative. *Allan McLane Hamilton.*

MYXOMA. The name myxoma, or tumor composed of mucous tissue, was first used by Virchow, who separated from the other connective-tissue tumors a special class of formations to which he gave this name. Before this they had been described under various names, which generally had reference to the soft and jelly-like character of the growth. Laënnec gave them the name colloid, because the soft, trembling, gelatinous character of the tissue reminded him of partially solidified gelatine. Those tumors described by Johannes Müller under the name gelatinous tumor, or collonema, belong in this category, although the latter name seems also to have been used for soft tumors of other sorts, as the soft fibromas, etc. Paget has described them under the name fibrocellular tumors.

Virchow distinguished as a separate variety of the connective tissue, *mucous tissue*, which was characterized by containing in the intercellular substance a quantity of mucin. This tissue was most developed in the fœtus, where it formed the jelly of Wharton in the umbilical cord, and was also abundant in the subcutaneous tissue. In the subcutaneous tissue it afterward became converted into fat, and when it was found elsewhere in the body Virchow regarded it generally as an antecedent to fat formation. Its cells either take up fat directly, and so become changed into fat cells, or they proliferate and the young cells so formed become fat cells. In the adult tissues it occupies but a small field, being found only in the vitreous body of the eye, and in the subcutaneous tissue in a few places, here principally over the pubes. Histologically, the tissue consists of cells embedded in a homogeneous matrix. The cells may be of various shapes, round, spindle- or star-shaped. Generally they have the latter form, and are abundantly provided with processes which freely anastomose with the processes of neighboring cells, and form a fine meshwork through the tissue. On section of the tissue, abundant fluid escapes, which has the same properties as those fluids which contain mucus. The mucin in the ordinary secretions of mucous surfaces is the result of the action of the epithelial cells, and is formed in them; but in the mucous tissue it is not found in the cells, but in the intercellular substance. The mucin contained in the fluid has some of the chemical properties of albumen, but can be distinguished from it in various ways. On the addition of alcohol to fluids containing mucin, there is an abundant precipitate formed, which can be distinguished from the albuminous precipitate, formed in like manner, by the fact that it swells up and dissolves on the addition of water. The albuminous precipitate is not affected by water. Mucin is not dissolved by an excess of the organic acids, but is readily soluble in an excess of mineral acids. The neuroglia of the central nervous system which forms the connective-tissue framework here, has much similarity to the mucous tissue, but differs from it chemically, and has no tendency to undergo the further metamorphosis (change into fat) which the mucous tissue has. The mucous tissue is to be regarded rather as a transition tissue.

The result of later investigations has been to throw much doubt on the existence of mucous tissue as a distinct type of tissue, such as Virchow has described it. Even in the place where he supposed it to be most typical, *i.e.*, in the umbilical cord, it has been shown that this is only ordinary connective tissue with an abundance of fluid in its meshes. A tissue almost analogous to mucous tissue is found in every subcutaneous œdema, and can be produced artificially by puncturing the skin with a fine hypodermic needle and injecting salt solution. A doughy swelling is so produced, and on section the injected fluid will not flow out again, but is held in the meshes of the tissue and along the fibres. On microscopic examination of sections, made by clipping out a piece of the swollen tissue with a pair of sharp scissors, the cells are found separated from one another, often anastomosing, and the fibres of the connective tissue do not appear so prominent. The fact that the supposed mucous tissue of Virchow contains mucin cannot be held as peculiar to it, and as distinguishing it from other forms of connective tissue. Mucin is found in all the connective tissues, and the gelatinous œdematous tissue does not contain any greater proportion of it than other tissues of its class. The fatty tissue which Virchow supposed to be developed from the mucous, does not stand in any immediate connection with this, but, according to Ranvier, takes its origin from cells which from the beginning are destined to form fat-cells.

Following this, Rumler and Koster have taken the ground that the myxoma is not to be considered as a special type or class of tumors, but that it simply represents conditions which might arise in any of the tumors which contain connective tissue. This myxomatous condition of the connective tissue consists in its saturation with serum in consequence of circulatory disturbances in the tumors, passive congestion, etc. They regard this tissue, wherever found, simply as ordinary connective tissue infiltrated with fluid, or œdematous. In every tumor there can be numerous conditions which might give rise to this. The veins can easily be compressed by the growth of certain parts of the tumor, and we cannot suppose that the vessels of a tumor of any sort are less prone to allow of transudation, in case of passive congestion, than those of any other tissues. On the contrary, it seems probable, from the numerous areas of small cell infiltration in tumors of every description, and from the frequency with which red corpuscles are found in the tissues, that the vessels are easily traversed by the corpuscular elements of the blood, and where this is the case the fluid elements pass through also. The serum would be most readily taken up in the meshes of the connective tissue, enlarging these, and the connective-tissue fibres would be forced apart and rendered less distinct. The fact that we scarcely ever find a pure myxoma, such as Virchow has described, but almost always this so-called myxomatous tissue in connection with some variety of tumors which contain connective tissue, as fibroma, sarcoma, carcinoma, etc., speaks much in favor of the correctness of this view of Koster. Still the term myxoma or myxomatous tissue, to denote this swollen and œdematous connective tissue, is a convenient one, and will be retained, although the myxoma, in the light of these recent investigations, should occupy no place in the category of tumors. The myxoma was first described by Virchow, and his descriptions of it are in all respects so full that they have undergone but little modification by subsequent writers on the subject. The writer has thought it best after this preface, which sheds a clearer light on what has been a complicated subject in *onkology*, to give, in the main, Virchow's description of the tumor.

The cells in the tumor vary in shape and in numbers, this variation depending chiefly on the stage of development of the tissue. The younger the tissue is, the more the cells are inclined to be round and the more numerous they are. In the older portions the cells are rather star- or spindle-shaped, and have numerous processes which

communicate freely with one another, producing a reticular or areolar tissue, in the meshes of which round cells are frequently enclosed. When these cellular elements are fewer in number, the whole tissue has a transparent, gelatinous appearance, and is similar to the vitreous body of the eye. This forms the variety myxoma hyalinum. Virchow has described several other varieties, which depend on various, for the most part minor, differences in the structure of the tumor.

Myxoma medullare. In this the cells are more abundant, and this gives the tumor a whitish, opaque, medullary appearance.

Myxoma fibrosum. In this the tumor contains a considerable amount of fibrous tissue, especially elastic fibres, which often form dense bands which appear on the cut surface.

Myxoma lipomatodes or myxo-lipoma. In this the tumor contains a considerable amount of fat, either in the shape of small drops contained in the cells, or as fully

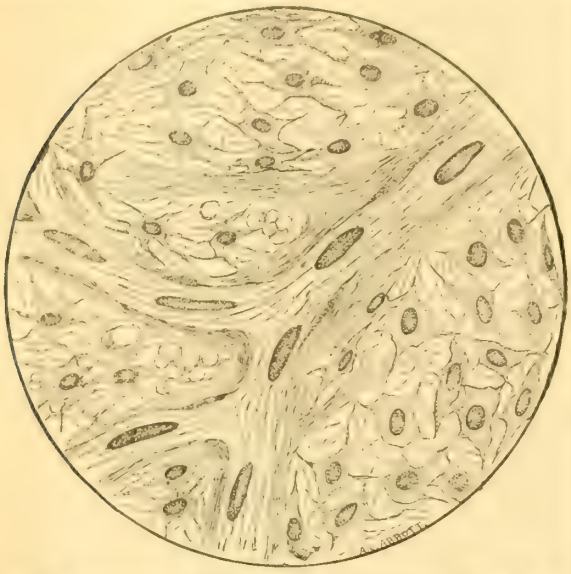

FIG. 2426.—Section of a Myxoma of the Subcutaneous Tissue of the Thigh. ×300.

formed fat-cells. There may be so much fat present that the tumor has most of the characteristics of lipoma.

Myxoma cartilagineum or myxo-chondroma. A large proportion of the myxomata contain islands of cartilage. This is especially the case in the compound tumors of the parotid gland and of the testicle.

Myxoma cystoides. In some cases the cells of the tumor enclosed in the mucous tissue undergo mucous or fatty degeneration, and large cavities are formed filled with viscid fluid.

Myxoma telangiectodes. As is the case with most tumors, the vessels here also may be enormously developed, and this name has been given to the condition.

Mucin is found in numerous other tumors, as a result of the physiological activity or of a degeneration of the tumor cells. It is found, for instance, in the cystic tumors of the ovary and in most other epithelial cysts. Virchow excludes these from the myxomata, and has limited this term to those tumors where the mucin is contained in the tissue and forms an integral part of the tumor. Billroth has included with the myxomata all such tumors, among them goitre. Just as the most typical formation of mucous tissue is found in the fœtus, the most typical examples of myxomata are found in tissues belonging to the fœtus. The myxoma of the chorion, forming what has been termed mole pregnancy, is the most typical example of this myxoma. Abortion takes place in this case at an early period, and the chorion will be found covered with transparent, gelatinous vesicles, which are connected with the membrane by a narrow pedicle. Sometimes several of these vesicles are connected with the same pedicle, and are strung along it like rows of beads. The vesicles vary in size from a pin's head to that of a nut. On microscopic examination they are found to be covered with epithelium, and composed of a tissue similar to that of the umbilical cord, *i.e.*, branched cells lying in a homogeneous matrix. Other parts of the fœtal appendages may be the seat of similar formations. Cases have been seen where the umbilical cord contained along its course a series of such vesicles. Also in the placenta itself there may be an abundant formation of mucous tissue in the form of circumscribed tumor masses. Retained portions of the placenta may form the starting-point of tumors which reach a considerable size.

In the adult the subcutaneous cellular tissue is the most frequent seat of the myxomata. Here they are principally found on the thigh, on the buttocks, on the labia majora, and the lower lip. The fat in the orbit may be a point of origin for the tumor. Such tumors may reach considerable size; those of the size of a child's head have repeatedly been seen. These large myxomata have a distinctly lobular structure, and when they break through the skin they become ulcerated and often very foul. They may have a deeper origin, as from the intermuscular tissue. In some localities, where the skin covering them is not tense, they become distinctly pedunculated.

The long bones are often the seat of this tumor. In this place it seems to originate in the bone-marrow. In these tumors various combination forms, with sarcoma and enchondroma, are seen. The spongy osteomata, with soft cellular marrow, may be confounded with them. The pure myxoma of the bones is a soft, spongy tumor, which ordinarily originates in the bone-marrow, and in the course of its growth becomes covered with a thin shell of bone. At a later stage it breaks through this and grows as a soft mass. It is always accompanied by a new-growth of bone, is generally lobulated, and here and there portions of the old bone may be enclosed in its substance. The tumor is soft and grayish-white or yellow. Virchow compares its tissue to the flesh of oysters. An abundant formation of blood-vessels may give a reddish tint to the tumor.

The myxomata often have a heteroplastic origin, and which is most frequently found in the central nervous system. A considerable proportion of the brain tumors belong in this category, especially those of the cerebral hemispheres. The dura mater of the brain and cord may also be the place of origin.

When seated on the peripheral nerves the tumor does not originate in the neurilemma, but in the interstitial tissue. Such tumors along the nerves are often mistaken for neuromata. They give rise to severe neuralgic pains, and are often multiple. All the nerves of an extremity may be affected, in some cases several being seated on a single nerve-trunk. In many cases the nerve does not pass into the substance of the tumor, but over it, and is generally flattened from pressure. It is often possible to dissect out the nerve from such a tumor and remove the tumor, leaving the nerve intact. The consistence of these tumors is so soft that they may be easily mistaken for cysts. They have a tendency to return after removal.

Myxomata may also be found in the glandular organs, where they arise from the interstitial tissue. Such tumors are found in the female breast. The tissue of the tumor grows into the milk-ducts in the form of polypoid masses. The duct becomes dilated into a cyst, which is filled with the branching growth. The whole tumor may in this way be enclosed in one large duct, and may be removed from it, leaving a cavity with smooth walls. On microscopic examination the section often appears to be composed of small islands of myxomatous tissue surrounded by epithelium. The islands of tissue are the cross-sections of the branching dendrate growth in the duct. This manner of growth is not peculiar to the myxomas of the mamma, but is seen also in fibromas and sarcomas in the same locality. The tumor finds the least resistance to its growth in the milk-ducts, and grows into and dilates these. Jungst has recently de-

scribed one of these tumors in which a great part of the tissue had undergone hyaline degeneration. When the superficial ducts are the seat of this growth the tumor may project as a nodular mass from the breast. This is particularly apt to take place in the region of the nipple. The skin covering the tumor becomes thin and finally breaks through, and a soft, fungous, often gangrenous, mass appears. This may have an appearance very similar to that of an ulcerated cancer. If it is closely examined, spaces may be found in which a sound may be pushed deeply down between the single masses of which the tumor is composed.

The mixed forms of the tumor deserve especial attention, for they are much more common than the pure forms. They are most apt to be seen with tumors of the connective-tissue type, as the fibroma and sarcoma, but may be found with any tumors which contain connective tissue. In the spindle-cell sarcoma the tissue may be seen to pass into myxoma. The cells become separate from one another by an increase in the interstitial tissue, and lose their spindle shape. In carcinoma the most typical mucous tissue may be found between the masses of epithelial cells. These mixed forms have been given special names, as carcinoma myxomatodes, etc. The fact of the presence of such tissue in a carcinoma or sarcoma does not influence the growth of the tumor, nor its prognosis, but may lead to errors in diagnosis. Wherever this tissue is present the tumor is softer. The mixed tumors of the parotid gland always contain a considerable quantity of myxomatous tissue.

In general the tumors described as myxomata are not malignant. Some, however, are. Those of the central nervous system are malignant from their position, and those of the peripheral nerves have a tendency to multiple formation and to return after extirpation.

The best and most typical pictures of this tissue are to be obtained by examining fresh sections made by the freezing microtome in salt solutions. After the tumor has been hardened in almost any of the hardening agents, the tissue loses its fluid and shrinks very much.

W. T. Councilman.

NÆVUS. A term including a number of hypertrophic new-growths of the skin of quite various character, but having all, or nearly all, the common character of being congenital. *Nævus vasculosus, nævus flammeus,* is a congenital new-growth of the blood-vessels of the skin, which will be found described at length below. *Nævus pigmentosus, nævus spilus, nævus verrucosus, nævus lipomatodes,* and *nævus pilosus,* all belong to the same group of hypertrophies of the pigment, with or without the involvement of other elements of the skin, and will also be found described below under the first designation. *Nævus papillaris, nævus unius lateris,* and *nerve nævus,* will be found described under the head of Papilloma, *q.v.*

I. Nævus Pigmentosus, or pigmentary mole, may consist simply of a circumscribed pigmentary deposit in the skin, without hypertrophy of the connective-tissue elements or of the hairy system ; or in addition to the excess of pigment there may be hypertrophy of all the cutaneous structures, especially the hair. Pigmentary nævi vary greatly in size and shape. They may be small, the size of a split pea or bean, or large, covering a considerable surface. The outline of the smaller lesions is usually roundish, that of the larger may be irregular. In color, moles vary from light fawn to jet black. When smooth on the surface, and level, or nearly so, with the skin, they have been called *nævus spilus.* When rough, uneven, and warty, they are called *nævus verrucosus.* Sometimes they are met with as thick, soft connective-tissue growths of variable dimensions, being then designated *nævus lipomatodes.* Sometimes pigmentary nævi are smooth and hairless, at other times they are more or less covered with hair. A good example of hairy nævus is seen in vol. iii., Fig. 1688, under Hirsuties.

Pigmentary nævi may be single or multiple. Hyde has described a case where a great number of scattered moles were distributed in bands on the left side of the trunk ; while De Amicis has seen a case where the whole cutaneous surface was covered with hundreds of disseminated blackish-brown moles, from the size of a pin head to that of a bean, some of which were hairy.

Moles may occur upon any part of the body, but are more common upon the face and trunk. Sometimes they appear over the course of nerve-tracts. The smaller moles are often acquired, while larger hairy nævi are congenital.

The treatment of pigmentary nævus consists in removal of the growth, when this is possible. The smaller lesions may be removed by the aid of caustic potassa, nitric or glacial acetic acid, or ethylate of sodium. Small hairy moles of the face are best removed by electrolysis, as described under Hirsuties. The same operation which removes the hair, removes the mole also ; of course a small scar remains, but this is comparatively insignificant.

Larger pigmentary nævi are to be removed by the knife, and a deep scar necessarily follows.

II. Nævus Vasculosus.—Vascular nævi are congenital formations composed chiefly of blood-vessels, which have their seat in the skin and subcutaneous tissues. They may be prominent, turgescent, erectile, or even pulsating, tumor-like growths (*angioma cavernosum, tumeur érectile*), or they may be flat, non-elevated, well-defined or faint, smooth patches (*nævus simplex*). The latter is the "mother's mark," or "port-wine mark," of popular language.

Angioma cavernosum is, in reality, rather a tumor of the deeper tissues than a disease of the skin, and will be treated of under the head of Tumors. The superficial form of vascular nævus may be either congenital or acquired. The latter variety will be described under the head of Telangiectasis.

Nævus vasculosus simplex occurs in the form of one, or sometimes several, spots, from the size of a small pin-head to that of the palm of the hand, or larger tracts. While these are usually level with the skin, the smaller ones are occasionally found raised like small red tumors. The color of the lesions varies greatly. Usually it is a bright red, but at times it has a deep port-wine tint. In some cases the color is like a stain or an erythematous blush. At other times tortuous blood-vessels may be seen coursing over the surface. Pressure by the finger causes a momentary pallor. The epidermis over the lesions remains unchanged. On superficial inspection the lesions seem sharply defined, but on closer examination the edge of the vascular area is seen to fade gradually into the surrounding skin.

As regards the cause of nævus, the explanation given by Virchow, namely, superfluous vascular formations in those portions of the embryo at which junction of the various parts takes place, seems most plausible. A small quantity of matter left over, squeezed out between the joints as it were, like superfluous building material, forms these nævi and the similar growths of lymphatics, hair, pigment, etc.

Nævus vasculosus simplex is most frequently met with about the head, and next to this upon the trunk, and then the extremities. Among 333 cases observed by Weinlechner, 243 were found upon the head. Of these 200 were in the face, of which 54 were frontal, 35 palpebral, 32 nasal, 30 labial, and 26 buccal. Of 20 cases of nævus of the face observed by the writer, 12 were in females, and 8 were in males. As regards position, 14 were on the right side, 4 on the left side, and 2 appeared to be symmetrical.

The pathological anatomy of these growths will be found fully described under the heading Angioma.

The treatment of vascular nævus, aside from the radical surgical measure of bodily removal by the knife or ligature, has one principle underlying it, namely, that of exciting enough inflammatory action in the growth to obliterate the calibre of the vessels composing it. This may be accomplished in any one of a number of ways. Minute nævi no larger than the head of a pin may be destroyed by puncture with a red-hot needle, or with a needle charged with nitric or glacial acetic acid, or by electrolysis, with the aid of one or more needles con-

nected with the positive pole of a four- to ten-cell combination of a constant current battery. When the growth is a little larger, from the size of a split pea to that of a ten cent piece, it may be treated by caustic applications. Of these sodium ethylate is one of the most efficient. It rarely causes severe pain, and may be applied on the end of a glass rod. Other caustics are nitric acid and glacial acetic acid, which are available in the larger as in the smaller sized nævi. Solution of caustic potassa is also occasionally used, although this is a remedy of dubious value, since, to get it strong enough for a proper effect on the tissues, we must make it so powerful as to run a risk of too rapid action and consequent hæmorrhage. Injections of tincture of the chloride of iron, with tincture of cantharides and the like, into the substance of the growth, have been recommended, but these methods are not without danger, and fatal cases of embolism have been reported as following the use of the iron solution. Vaccination has long been practised in suitable cases. The virus must be pricked in with needles at a suitable number of contiguous points simultaneously. Linear scarification, as used in telangiectasis and rosacea, may occasionally be employed, but this, as well as punctiform scarification, when used with uncharged points, will usually be found unsuccessful. The galvano-cautery and Paquelin's cautery have also been used.

The prognosis of nævus vascularis is usually favorable. The growth gives rise to little or no sensation, rarely increases in size, and sometimes disappears spontaneously. Occasionally, however, the smaller and prominent growths undergo malignant change, and this, as well as their unsightly appearance, should be considered by the physician who may be called upon for an opinion as to the advisability of treatment.

Arthur Van Harlingen.

NAIL. By the term nail is understood only that part which rises above the surface of the skin. The matrix, like the hair-papilla, although the seat of origin of the nail, and strictly speaking part of it, is here excluded from consideration. With this idea in view, we define the nail as a flattened elastic structure of a horny texture, placed upon the terminal phalanges of the fingers and toes. Each nail is convex upon its outer surface and concave within, and is implanted in a groove of the skin, from which, and from the entire floor of the nail-fold or matrix, as far forward as the border of the lunula (*lunula*, "little moon;" the semi-lunar white portion of the nail nearest the root) it originates. From this point the nail bends forward in the form of a thin, curved plate, in closest connection with the nail-bed, but receiving no further structural contribution from the latter, and finally terminates in the free edge or extremity.

As regards the method of growth in the nail, this is to be viewed as not unlike that of a hair, growing straight up in the air, so to speak, from the nail-fold or matrix, and only bent at the very top. Layers of horny matter heaped up parallel to one another are secreted by the matrix, and this not, as one would at first think, straight up from the whole surface, but in a somewhat more complicated manner, which perhaps can be better understood by reference to the cuts.

If in imagination we now consider the bending over of the whole mass, according to Unna's description, we see that the horny filaments which pass over the *surface* of the nail come from the most posterior part of the nail-fold; those which run through its middle, from the middle, and the undermost from the anterior portion of its floor which terminates in the lunula. Changes in the *upper* surface of the nail must therefore be referred to the bottom of the nail-fold, those of the *under* surface to the region of the lunula. It is also evident that if we seek inside the nail for the cells which were produced at one and the same time by the matrix, we shall find them in a plane parallel to the latter, and running obliquely downward and forward (as in Fig. 2427, *I*, *nm*; *II*, *nm*), not, as is usually believed, in an artificial vertical cross-section of the nail. For this reason, the narrower the nail-fold (as in Fig. 2427, *II*) the more rapid the growth of the nail, but the less its thickness; and, *vice versa*, a nail may increase in thickness without growing out so rapidly. The growth in thickness or in length, respectively, is governed by the relative activity of the cells in the nail-fold and of those in the extremity of the lunula.

The papillary layer of the substratum of the nail is seen in cross-section, in Fig. 2427, *III*. It is divided into several areas covered with rows of papillæ. The vascular supply of the nail-bed is very peculiar, resembling in some respects an erectile tissue, such as that of the corpora cavernosa.

The greater part of the surface of the nail is free, but it is covered behind and at both ends. The substratum is composed of loose connective tissue, containing

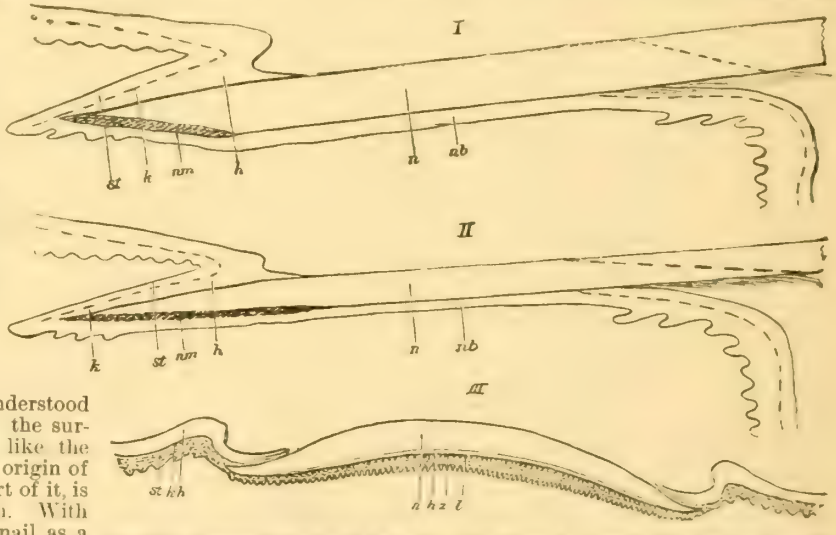

FIG. 2427.—Schematic Section of the Nail. (After Unna.) *I*, longitudinal section through a thick nail. *II*, longitudinal section through a thin nail: *st*, prickle-layer of roof of nail-fold; *k*, granular layer of roof of nail-fold; *h*, horny layer of roof of nail-fold; *n*, nail; *nb*, nail-bed. *III*, transverse section of a nail; *l*, ridges of the nail-bed; *z*, dentate processes of the nail; *h*, clear lower part of the nail (erroneously called the horny layer of the nail-bed); *n*, nail; *st*, *k*, *h*, prickle, granular, horny layer of the epithelium at the sides of the nail-fold.

convoluted glands and fat, the vessels of which communicate with those of the surrounding corium, and with those underneath the nail. The epidermis has the usual three layers, the horny layer predominating as the free end of the nail is approached. The cross-section given above, Fig. 2427, *III*, shows the corium at about the centre of the nail. This is attached to the nail-bed by minute prolongations or dentate processes seen in the cut at *z*. Though thus attached there is, as has been said, no growth of the nail from this part of the bed, which is anterior to the lunula. The lunula owes its white color to the fact that the matrix here contains a number of absolutely opaque elements which scatter the light. These are the transition cells, or keratogenous cells, midway between the prickle cells and the nail cells proper.

According to Beau, the nails of the hand grow at the rate of about one millimetre per week, those of the foot about one millimetre per month. The thumb-nail being, on an average, about two centimetres in length from the posterior border of its root to the beginning of its free edge, passes through all the phases of its evolution in about one hundred and forty days. Dufour differs some-

what from Beau, giving the period of growth as from one hundred and twenty-one to one hundred and thirty-eight days in the different nails.

Pathology and Therapeutics.—Under this head are to be considered only those affections which involve the horny substance of the nail itself, and which, in almost every instance, proceed from some influence exerted upon the matrix. The affections known as onychia and paronychia, involving the nail plate only secondarily, will be found discussed under Whitlow.

Hypertrophy of the Nail.—This may include an increase in the number of nails, or in the substance of one or more individual nails. Instances of the former are observed as an anomaly, and comprise the occurrence of nails on the last phalanx of supernumerary fingers and toes, the presence of double nails on one finger or toe, or the occurrence of completely or imperfectly developed nails at unusual points, as on the end of the first phalanx after an amputation, on a metacarpal stump, etc., or as a malformation in the region of the scapula.

Increase in the substance of the nail may take place simply as a thickening, or as a general enlargement of the whole substance of the nail. Both are known as *onychauxis*. In the first form the nail is unshapely, thick, opaque, glossy on the surface, or spherically curved, and of a grayish-white color, has a massive feel, is heavy, and so hard that it can only be cut by a saw. When the change affects the whole nail it often shows at its free border a tendency to curve downward. In the second form of hypertrophy, should the nail increase in a lateral direction, the effect is felt in the soft parts; should it increase longitudinally, it may grow several inches in length, curving and twisting grotesquely, and forming the deformity known as *onychogryphosis*. Onychogryphotic nails have a dirty yellow, brownish, or grayish color with a shining lustre, and are marked with longitudinal and also transverse ribs, with occasional horny plates. The under surface is usually brownish, with an irregular, flaky exterior interrupted by smaller or larger cavities, and crossed here and there by transverse ridge-like projections. The anterior portion of the matrix, and the entire area of the nail-bed, are shown by microscopical examination to be in a chronic state of irritation.

Onychauxis may be congenital or acquired. At birth the nail may be only slightly developed in excess of its normal average, but it grows with a greater relative rapidity. The various diseases associated with papillary hypertrophy (*e.g.*, ichthyosis) seem to favor the development of this inborn tendency in the nail. More commonly onychauxis is acquired and may be traced to some traumatic cause—to neglect, to the extension of morbid inflammatory processes of the corium and the connective tissue of the cutis to the matrix of the nail (*e.g.*, psoriasis, chronic eczema, lichen ruber, lepra Græcorum, elephantiasis Arabum, etc.). Some predisposition to onychauxis must, however, exist in these cases, as not every case of these diseases shows hypertrophy of the nail (some even show atrophy), and as, furthermore, the nails are, at times, affected when the skin disease does not exist in contiguous parts.

Symptomatically, hypertrophy of the nails sometimes occurs in neuropathic affections of a degenerative or irritative character—most frequently in spontaneous neuritis, neuralgia, chronic myelitis, traumatic lesions of mixed nerve-trunks ("glossy skin"), etc. The same alteration of the nails may occur after various chronic diseases, as articular rheumatism, affections of the bones, or ankylosis. Partial hypertrophy may occur after various ulcerative processes in the nail-bed, in which the remaining part of the matrix appears to attempt to make up the loss.

The effect of hypertrophy of the nails is not only cosmetic deformity, but absolute loss of tactile sense to a greater or less degree. The person is unable to execute delicate or fine work. Fortunately onychogryphosis of the fingers is rare, and even onychauxis to a marked degree is uncommon. When the toes are affected, walking may be more or less interfered with, and in advanced cases may become altogether impossible. Lateral hypertrophy may produce inflammation and ulceration in the surrounding soft tissues (ingrown toe-nail).

The prognosis in hypertrophy of the nail depends upon the chance of removing the cause. Of course the hypertrophied nail can in no wise be altered, but if the eczema, psoriasis, etc., can be cured, there is good reason to hope that a healthy nail may be developed from the matrix. In the case of such diseases as lepra or elephantiasis, where the disease is incurable, but little hope can be entertained of improving the state of the nail. The same is true when the matrix has been altered by traumatic influences to an irremediable extent.

The treatment consists in removing the cause when attainable, and in doing away with the hypertrophied product when this becomes a serious annoyance. The nail may be removed by means of the knife, cutting pliers, or in extreme cases, the saw. Where the nail has enlarged in width it may press upon the lateral furrow to a greater or less extent, and when to this is added pressure from a tight shoe, considerable irritation and inflammation of the soft parts may ensue, followed in extreme cases by great destruction of the neighboring tissues, even involving the tendons and bone. The treatment of this form of the disease will be described under Whitlow.

With regard to the treatment by removal of the cause, if eczema, psoriasis, or other disease exists, this must be removed by appropriate local remedies, ointments, rubber finger-stalls, etc. When eczema is present on the body, iron, arsenic, and other remedies appropriate to these affections of the skin will also be found to affect the nails favorably. When the disease of the matrix and nail-bed is due to any form of syphilis, internal treatment appropriate to that disease is called for, and, in addition, the local application of powdered iodoform, mercurial ointment, or solution of corrosive sublimate, 1 to 250 of water.

When the cause is traumatic, as from an ill-fitting shoe, this should be remedied, or when from severe occupation, protection of the finger or toe by soft wax or other mechanical device.

Atrophy of the Nail, like hypertrophy, may be congenital or acquired. The congenital form is met with in connection with imperfectly developed fingers and toes, the nail being either entirely absent, imperfectly developed, mutilated, or coalescing with other nails.

The acquired form of atrophy of the nail is met with as a result of traumatic influence, as pressure of shoes, etc., which at times may produce hypertrophy, and at other times atrophy. The nail formation may also be hindered by a knock, blow, pinching, etc. Geber, upon whose writings this article is chiefly founded, looks upon white spots on the nails as an insufficient cornification of the nail-cells, traceable to mechanical influences.

Thermic and chemical sources of irritation are not uncommon causes of atrophy of the nail, as are also inflammations associated with suppuration and ulcerative processes.

Among the constitutional causes of retarded nail-growth are febrile conditions and chronic wasting conditions of the general organism. Typhoid fever on the one hand, and tuberculosis on the other, may be mentioned as typical causes. Those cutaneous diseases and nervous affections which produce hyperplasia of the nails, such as ichthyosis or ataxia may, under other conditions, give rise to precisely the opposite effect.

The imperfectly developed nail is whitish-gray, lustreless, thin, and delicate, giving the impression of a thickened membrane; possessing but slight hardness, readily broken, and flexible. At times the substance is so friable that it exfoliates longitudinally, and fractures through its thickness, thereby rendering the nail uneven.

The treatment includes first, frequent trimming and covering of the affected nail with a protective layer of wax. The removal of the etiological factor is next to be attended to. The main point is to keep away any possible injurious influences, to cure, if possible, any accompanying skin diseases, dyscrasic or nervous affections, inflammations and ulcerative processes, and to support

the strength of the patient when impaired nutrition may be the cause. When the defective nail formation is due to some incurable disease, it is, of course, impossible to expect a change for the better. Geber thinks that equable pressure exerted by strips of adhesive plaster upon a wax nail fastened to the nail-bed will hasten the regeneration of the nail.

Deformity of the Nail.—Deviation in form, degeneration, or discoloration of the nail, are all deformities of the nail as distinguished from simple hypertrophy, and are due to various causes.

Malformation of the nail-plate is a result of disturbed function of the matrix. The latter may be the result of nerve-disturbance (paralysis), of injury, malformation of the lateral furrow, inflammation of the underlying connective tissue, periosteum, bone, etc.

Nails suffering from deformity may be long, short, narrowed, or curved one way or another, occasionally pointed. The writer has reported a case where the nails were curved or rolled in at the edges so as to present a semi-cylindrical figure, and so shrunken that they occupied only about one-half the normal width of the nail-bed. The case was that of an infant suffering from hereditary syphilis. The deformed nails were gradually replaced by normal ones as the infant regained health under treatment.

Sometimes deformity of the nails may be hereditary. As the cause can rarely be removed, the affection is usually irremediable. Fortunately, it is rarely more than a mere disfigurement.

Degeneration of the nail may occur as a result of faulty nutrition, but is also met with following chronic inflammatory processes (paronychia sicca) of the matrix. The nail may be thick or thin, or more frequently fibrous, and spread with an irregular detachment of particles. The color changes to a grayish-white or dirty yellowish-gray. Aside from disfigurement these nails are very troublesome, as they are continually breaking and splitting, and occasionally denude the nail-bed. Removal of the cause, when this can be ascertained, and protection by the wax nail-covering and bandage, may be recommended when practicable.

Discoloration of the Nail is only worthy of a passing notice. The changes to purple, to chalky-white, to yellow, etc., in various diseases, are probably due only to the translucency of the nail showing the congestion or discoloration of the tissues beneath.

Traumatic and chemical injuries may affect the texture of the nail from a distance. Thus, workers in acids, etc., and those who use peculiar tools, may have alterations in the nail following long-continued action at a distance. The animal and vegetable parasites may also affect the texture of the nail.

Parasitic Diseases of the Nail.—The itch insect, sarcoptes scabiei, may give rise to various changes in the nail. Boeck states that the eggs and excrement of the sarcoptes are to be found in the degenerated nail-substance. Bergh has shown that the deviations in the nail due to the sarcoptes are brought about on the one hand by affection of the nail-bed and matrix, and on the other by implication of the nail substance.

The collective result of these influences is that the nail-bed becomes thereby hypertrophic and greatly bulged out longitudinally in the middle. The lower surface of the nail itself is studded all over with irregular projections and hollows, often even deeply excavated or conically depressed. The nails assume a horny or claw-like appearance, and are considerably thickened, yellowish or brownish in color, and on section show an asbestos-like whitish or yellowish, flaky or fibrous, appearance. On microscopic examination Bergh found itch mites, eggs, egg-shells, burrows, skins, and excrement of the parasites in the substance of the nail. The writer has never observed scabies of the nail, and is inclined to think that the disease does not exist among our more cleanly population.

Various tropical flies, which lay their eggs under the nails, may cause disease, but none of these is so harmful as the sand flea (*Pulex penetrans*), which causes at first violent pain and, following this, paronychia.

Vegetable parasitic diseases of the nails are less uncommon than those caused by animal parasites. The disease is more apt to spread from the adjacent skin than it is to be implanted directly under the nail. The onychomycoses are, so far as yet known, of only two kinds, that due to favus, and tinea tricophytina. The clinical appearance is not very different, and will be described once for both. Favus is the more rare. The nail affected shows signs of change at an early date after the implantation of the fungus, becoming brittle, frayed out, and intersected by furrows, and presenting a discolored, opaque, grayish or yellowish-white appearance, and is more or less lifted up. When the process has continued for a considerable time the alteration extends to the entire nail, and the matrix being implicated, changes in growth are perceptible. The nail becomes claw-like, thickened, flakes off even on the surface, and being detached here and there, and acquiring a faded, dirty yellow color, becomes exceedingly disfiguring. Rare cases of favus infiltration of the nail show the peculiar sulphur-yellow crusts or scutulate depressions; but the worm-eaten appearance produced by numerous other affections must not be mistaken for this, and, in fact, apart from the actual discovery of the fungus, an exact diagnosis cannot often be made. In this country, moreover, parasitic disease of the nail is excessively rare, and, in fact, the writer is not aware of any case of the kind having been reported, with the exception of Duhring's case of tinea tricophytina unguinum, which was also under his own observation.

Longitudinal or transverse sections through a nail changed by the infiltration of fungus, show disintegration of the substance, and by treatment with glycerine, convoluted threads of mycelium and conidia mixed with cornified epithelium, can be observed under the microscope.

Authorities Used in the Compilation of the above Article.
Unna: Anatomy and Development of the Nail, Ziemssen's Handbook of Diseases of the Skin: American edition.
Geber: Morbid Changes of the Nail and its Bed, ibid.
Dictionnaire Pratique, etc., art. Ongle.

Arthur Van Harlingen.

NAPA SODA SPRINGS. *Location and Post-office*, Napa Springs, Napa County, Cal.

Access.—From San Francisco by California, Pacific & Northern Railway to Napa City, thence by stage to the springs, six miles.

Analysis (Lanzweert, Walton).—One pint contains:

	Grains.
Carbonate of soda	1.138
Carbonate of magnesia	3.265
Carbonate of iron	0.980
Carbonate of lime	1.360
Chloride of sodium	0.650
Sulphate of soda	0.230
Silicic acid	0.085
Alumina	0.075
Loss	0.310
Total	8.093

Therapeutic Properties.—These waters belong to the alkaline-chalybeate class.

These springs, of which there are a great number, flow from the slope of the valley about one thousand feet above the bottom level. From one of the springs is collected the "Napa Soda" water, highly charged with carbonic acid gas, and extensively used throughout California. *G. B. F.*

NAPHTHALENE. Naphthalene (improperly also written "naphthalin") is a hydrocarbon ($C_{10}H_8$) standing, like benzene, as the fundamental member of a series of aromatic compounds. Naphthalene is a common constituent of tars, and is obtained from coal-tar by fractional distillation. Naphthalene, when purified, presents itself in large, colorless, crystalline, rhombic plates of a pearly lustre and an unctuous feel. It has a burning taste and a faint peculiar odor. It is insoluble in water, but dissolves in alcohol, ether, benzene, oil of turpentine, glacial acetic acid, and warm oils, both fixed and volatile. It melts at 79° C. (174.2° F.), and boils at 218° C.

(424.4° F.), but yet sublimes at a much lower temperature than that of its boiling-point, and, mixed with boiling water, rises in vapor with the steam. Even at ordinary temperatures a gradual sublimation occurs.

Naphthalene is, locally, but slightly irritant, and constitutionally is not at all poisonous—a circumstance possibly largely dependent upon the insolubility of the hydrocarbon in aqueous fluids. Yet naphthalene is decidedly "antiseptic" in the common medical sense of the word. Taken internally, some absorption certainly occurs, since naphthalene, swallowed, reappears in the urine. Naphthalene has been used in medicine to prevent decomposition of the urine in cystitis, by administration, by the mouth, of an aggregate of five grains daily; but its main use has been in surgery, as a so-called antiseptic dressing for wounds. In this application naphthalene combines the features of a fair degree of efficiency on the one hand, and freedom from irritant or poisonous effects, and from offensive smell, on the other. The only untoward effects charged against naphthalene so far have been, that the sharp points of the crystals may mechanically wound tender granulations, and that the powder may cake with fluid exudates, and so tend to obstruct the free drainage of discharges. Most reporters upon the use of naphthalene in surgery, however, have failed to observe either of these effects. Naphthalene may be applied in bulk, in fine powder, to wound surfaces, or by means of gauze or wool charged with the substance, by the device of steeping the dressing in a strong solution of naphthalene, and then permitting the solvent to evaporate. By this means a porous material becomes thoroughly impregnated with a fine powder of the hydrocarbon. A common solution for the making of such dressings is a twelve and a half per cent. solution of naphthalene in a mixture of alcohol and ether in equal proportion. [See also Naphthalin in the article on Antiseptics in Surgery, vol. i., p. 264.] *Edward Curtis.*

NAPHTHOL. By the substitution, in the molecule of the hydrocarbon *naphthalene*, of a molecule of hydroxyl (—OH) for one of the atoms of hydrogen, a derivate, $C_{10}H_7.OH$, is obtained, bearing precisely the same relation to naphthalene that common phenol ("carbolic acid") does to benzene. Such derivate is styled *naphthol*, and according to the position in the naphthol-molecule of the hydroxyl substitution, two distinct naphthols are obtainable, known respectively as *α-naphthol* and *β-naphthol*. Of these two bodies *β-naphthol* is the easier made, is the article used in medicine under the simple title *naphthol*, and is what will now be considered.

The common naphthol of the markets is an impure article, occurring in reddish or deep violet-brown crystalline masses of a disagreeable, pungent, smell. Such a naphthol, because of the poisonous nature of some of the impurities, needs purification for medicinal use. Properly purified, naphthol presents itself in beautiful silver crystalline scales, nearly or entirely odorless, but of a sharp, burning taste. The crystals are very slightly soluble in water (in 520 parts of cold, and in 75 parts of boiling water), but dissolve freely in alcohol, ether, chloroform, benzol, and oils. Gently heated, naphthol sublimes, and may be distilled with steam. Naphthol is, locally, distinctly irritant, exciting upon tender surfaces redness, smarting and even inflammation, and, upon the healthy skin also, if in *alcoholic* solution, acting with sufficient energy to occasionally develop an eruption resembling nettle-rash. Solutions in oils or fats, however, are said to be without effect upon the sound skin, although acting energetically upon an eczematous surface (Kaposi). *Constitutionally*, the effects following the absorption into the circulation of naphthol, have been discrepant. Some experimental dosings of animals have been followed by hæmoglobinuria, with convulsions and death, and, in one instance in the human subject, an external application of naphthol produced hæmaturia, ischuria, unconsciousness, and eclampsia (Kaposi). Yet, on the other hand, as ordinarily applied externally, the medicine, though showing the fact of absorption by a discoloration of the urine, produces no constitutional disturbance; and the pure article, swallowed experimentally by the human subject in the quantity of from eight to ten grains daily, has deranged no further than to excite some warmth in the epigastric region, and slight vertigo and buzzing in the ears (Shoemaker). A possibly true explanation of the discrepancy of these various results may be, that the toxic effects occasionally observed after the use of naphthol have been due to impurities in the sample employed. Naphthol is reputed to be an efficient *antiseptic*, in the ordinarily applied use of the word, and may be employed in surgery in one-tenth per cent. solutions. The article is also used as a local application in many skin diseases, notably *scabies*, *psoriasis*, and *eczema*. It is commonly applied in ointment ranging in strength of naphthol from one-half per cent. to ten per cent., or even fifteen per cent. The remedy should not be used upon denuded parts, and weak applications only made to irritated parts such as so commonly present themselves in eczema. *Edward Curtis.*

NASSAU. The town of Nassau, capital of the Bahama Islands, lies on the north shore of the Island of New Providence, at a distance of about two hundred miles due east from the southern point of the Florida peninsula, and about thirty miles north of the parallel of latitude which passes through Key West. The exact latitude of Nassau is 25° 5′ 36″ N., only two degrees north of the Tropic of Cancer; its longitude is 77° 21′ 15″ W. Although Nassau is the largest town in the Bahamas, its population probably does not exceed ten or twelve thousand. The writer on Nassau in the "Encyclopædia Britannica" puts the figure for population at about eight thousand; and the highest estimate I have seen is twelve thousand seven hundred.[1] The Island of New Providence has an extreme length from east to west of nineteen and three-eighths miles, an extreme width from north to south of about seven miles, and an average width of about five miles. The highest ground in the island is but one hundred and twenty feet above sea-level, and nowhere throughout the whole group of the Bahama Islands, many of which are very much larger than New Providence, does the surface attain an elevation above sea-level of more than two hundred and thirty feet.[1] "The formation of all the islands is the same—calcareous rocks of coral and shell hardened into limestone, honeycombed and perforated into innumerable cavities, without a trace of primitive or volcanic rock; the surface is as hard as flint, but underneath it gradually softens and furnishes an admirable stone for building. . . . The soil, although very thin, is very fertile. . . . Except in the Island of Andros, no streams of running water are to be found in the whole group."[2]

The town of Nassau "extends along the water-front for about three miles and back to the crest of a slope, on which stand the Government House and many of the finest private residences, at an elevation of 90 feet above the harbor. The streets are laid out at right angles with each other, and are uniformly macadamized, as are also the numerous excellent drives around the island; and the houses are generally built of stone, with the surrounding grounds ornamented with a tropical profusion of flowers and trees."[3] As for the general character and appearance of the country back of the hill just mentioned, we read, in Mr. Charles Ives's work entitled, "The Isles of Summer," that, "with the exception of a very few square miles occupied by Nassau and its suburbs, there is little upon the island, except water and wilderness; the former is brackish and throbbing, and in some places appearing and disappearing with the long pulsations of the sea's diurnal tides, and the latter, to a large extent, a dense, low jungle, with stretches of pine forests rising from a thick undergrowth of scrub palmettoes."[1]

Turk's Island, and Dunmore Town, on Harbor Island, are other health-stations or winter resorts of the Bahamas, but I possess no detailed information respecting either, and practically it is true, as stated by Mr. Ives,[1] that "Nassau is New Providence and the Bahamas."

The climate of Nassau is tropical, and far warmer than

that of the Bermudas; but for the fact that the Bahama Islands lie in the track of the trade winds, and for the fact that they are islands of small size and of rather sparse population, the climate could hardly fail to be an unhealthy one; as it is, the climate may be regarded as a healthy one, at least during the colder months of the year. The following figures, derived from one year's observations, were sent me by the superintendent of the Canadian Meteorological Service, being kindly procured by Mr. H. Beaumont Small, of Ottawa. They show the mean temperature of each of the twelve months of the year in question:

January, 69; February, 73; March, 76; April, 78; May, 79; June, 83; July, 87; August, 88; September, 87; October, 80; November, 74; December, 70. Yearly mean, 78.7.

The data of Table A, show the "Mean of Daily Observations on Week Days, for Ten Years, from 1855 to 1864." This table is quoted from Mr. Ives's book, where it is "copied from the official report of Governor Rawson for 1864, page 14, compiled from the records kept at Nassau's Military Observatory." Governor Rawson's conclusions,

TABLE A.

Months.	Thermometer at 9 A.M.			Wind at 9 A.M.	Rainfall on ground in month.
	Max.	Med.	Min.	Four chief points, in order of prevalence.	Inches.
January..	75	70	66	N.E., E., S.E., N.	2.4
February.	76	71	66	N.E., E., S.E., S.	2.4
March....	78	72	66	E., S.E., N.E., N.	4.5
April....	81	75	68	N.E., E., S., S.E.	2.4
May	84	78	71	N.E., S.E., E., S.	6.9
June.....	88	81	74	S.E., E., N.E., S.	6.4
July	88	82	75	E., S.E., S., N.E.	6.5
August...	88	81	75	E., S.E., S., N.E.	6.7
September	86	81	75	E., N.E., S.E., N.	5.2
October...	82	77	73	N.E., E., S.E., N.	7.4
November	79	74	70	N.E., E., E., S.E.	2.8
December.	77	73	69	N.E., E., S.E., N.	2.4
Average ..	82	76	71	.....	4.6

based upon this table and upon others given in his report, are also quoted by Mr. Ives, and from them we extract the following statements: "The greatest maximum heat exceeds the average heat by not more than 12; the greatest minimum falls short of it 10°. . . . From May to October . . . the rainfall amounted to forty-four inches, and during the remaining six months to nineteen inches. . . . Northeasterly and easterly winds are the most prevalent from September to February, during which months they blow during one-half or two-thirds of the whole time. Northerly winds seldom blow, except during those months, and then only for three days in a month." As for northwest winds, the bane of the Atlantic coast of North America during the winter season, they occur "from November to March, about two days in a month." "The Bahamas," says Mr. Ives, "are slightly but agreeably refreshed by the coldest winds that ever reach them from the north and west." The relative frequency of the winds from the different points of the compass is given by Mr. Ives, in a table quoted from Governor Rawson's report, showing "the percentage proportion of days in a year during which they prevailed at 9 A.M.," as follows:

North	7.2 per cent.	South.....	11.0 per cent.
Northeast	26.2 "	Southwest	5.0 "
East	24.4 "	West...	2.3 "
Southeast	18.6 "	Northwest.....	5.3 "

In Table B the reader will find data, derived from official reports, and quoted from two tables in Mr. Ives's book,[1] one of which presents data for the year 1878, the other data for 1879.

The maximum and minimum temperatures, and the rainfall for each month of the year in the three years, 1880 to 1882, are published in one of the English "Blue-books" for 1884 ("Statistical Abstract for the Several Colonial and Other Possessions of the United Kingdom in Each Year from 1868 to 1882"), which was kindly

TABLE B.

(Two Years' Observations.)

	Absolute maximum temperature at 9 A.M.	Absolute minimum temperature at 9 A.M.	Absolute sun maximum in 24 hours.	Average Rainfall.	Mean number of rainy days.
	Degrees.	Degrees.	Degrees.	Inches.	
January.....	77.0	61.0	145.0	3.03	11.0
February.....	78.0	62.5	148.0	4.17	9.5
March	82.5	65.2	153.5	2.60	6.5
April.....	82.8	70.0	154.0	1.80	6.5
May	86.5	70.5	156.5	5.56	10.0
June	89.8	71.0	155.0	9.66	16.5
July	89.5	71.2	159.0	6.74	19.0
August	88.8	77.0	157.9	9.55	15.5
September.	87.5	70.0	153.5	7.58	22.0
October	85.0	74.5	153.0	6.93	15.25
November.....	81.5	66.5	157.5	5.41	8.0
December ...	78.2	65.8	155.0	1.49	9.0

sent me by Mr. H. B. Small. Without quoting these in full, suffice it to say that the absolute minimum temperature throughout the whole three years of observation was 64° F., occurring in March, 1881; that the absolute maximum was 90° F., occurring in July and in August of the same year; and that the average monthly rainfall for each of the six months, November to April, was as follows: November, 1.5 inch; December, 1.5 inch; January, 2 inches; February, 1.8 inch; March, 1.5 inch; April, 2.1 inches. Mr. Ives's rainfall statistics for 1879 correspond very closely with those just given, and the higher average figures found in Table B are caused by the exceptionally heavy rainfall of 1878.

Despite the high figures for minimum temperatures which have been given in the accompanying tables, I find a writer in the New York *Times*, Mr. William Drysdale, referring to the occurrence of a temperature of 55 at Nassau, and speaking of the desirability of securing at the hotel one of the few rooms in which a fire may be had in cold weather. He also complains of the strong wind which prevails at Nassau. This same writer alludes to the dryness of the winter climate; but I find nowhere any humidity statistics to corroborate or to qualify the accuracy of such an expression. It seems unlikely that the figures for relative humidity should be low on a tropical island.

Excellent sea-bathing may be enjoyed at Nassau throughout the year. Yachting and boating are favorite pastimes, and the facilities for both are excellent. The chief hotel at Nassau is under the supervision of the British Government, and is well kept. The water-supply is derived from tanks, and the quality of the water, at this hotel at least, appears to be good. As pointed out by Mr. Ives, this good quality is contingent, of course, upon the exercise of due vigilance in keeping the tanks clean. Mr. Ives tells us that there is no general sewerage system at Nassau, and utters a word of warning respecting the possibility of contamination of the water in such wells and cisterns as are "sunk in the soft, porous limestone rock in the vicinity of cesspools and privy vaults."[1]

Concerning the healthfulness of the central portion of the island, he says, "That the seeds of disease, at least during the night, float in the air above the swamps and lagoons of the central portions of the island of New Providence, is apparent to any thoughtful observer who either crosses it or sees it from any of the neighboring hills." On the other hand, of the city of Nassau itself he says that it is "in a sanitary point of view very favorably situated. Bottomed upon a rock of porous nature, which dips toward the harbor, and speedily absorbs or carries off the heaviest rainfalls; facing the north and skirting the sea; having within its limits no low and wet lands, the prevailing winds come to it from the ocean laden with refreshment and health." The south winds he complains of as being "very sultry, debilitating, and exceedingly disagreeable," and he believes them to be "unfavorable to health," by reason of having passed over the "low, wet surface of the centre of the island." The south wind at

Nassau is, however, a comparatively rare wind, as shown by the statistics previously quoted from Mr. Ives's book. As to the occurrence of epidemic diseases in the Bahamas, Mr. Ives says, "We did not learn of any cases of yellow fever, cholera, or small-pox from 1864 to 1879." A malignant fever which occurred in the winter and spring of 1880, and which "resulted in quite a number of deaths at Nassau," Mr. Ives believes to have been yellow fever, but he gives no positive proof that it was so.

Respecting the class of invalids who should be recommended to resort to Nassau during the winter season, it is difficult to speak with any approach to precision. Advanced cases of phthisis, in the writer's opinion, should not be sent thither. Catarrhal affections of the pharynx, larynx, and bronchi would doubtless be relieved by so warm and equable a climate, and incipient cases of phthisis might also be benefited in like manner. Many such cases have no doubt experienced great benefit from temporary sojourn at Nassau. For those who are suffering from the effects of overwork, the climate is a good one. As a general rule, perhaps it would be safe to say that any patient likely to be benefited by a stay at one of the warmer seaside resorts of the Middle States during the summer, would be likely to benefit by a stay at Nassau during winter. I should hesitate to recommend any person liable to suffer from mental depression to resort to an island possessing so little variety of scenery and occupation, and having its communication with the mainland only at intervals of a week. Inaccessibility is a leading fault in the case of Nassau. Much detailed information respecting the climate, scenery, flora, fauna, etc., of the Bahamas may be found in Mr. Ives's book, already so frequently quoted, but the book is perhaps better fitted to lay than to medical readers. *Huntington Richards.*

[1] Charles Ives, M.A.: The Isles of Summer, etc.
[2] Encyclopædia Britannica, vols. iii. and xvii.
[3] Appleton's Handbook of Winter Resorts.

NASTURTIUM (*Cresson de fontaine*, Codex Med.). The European Watercress, an herb with pungent, rather

Fig. 2428.—European Watercress (*Nasturtium officinale* R. Brown).

agreeable, spicy taste, often used on the table as a salad, and having antiscorbutic qualities. See Mustard.

W. P. Bolles.

NAUHEIM is a spa in Hesse-Darmstadt, lying at the foot of the Johannisberg, at an elevation of about four hundred and sixty feet above the level of the sea. The climate is mild, and the season is rather long, extending from the first of May to October. There are several artesian wells which furnish a water rich in mineral constituents. The following table shows the proportion of salts in four of the most commonly used wells, as given by Kisch in Eulenburg's "Real-Encyclopädie." The figures represent grammes per litre:

	Friedrich Wilhelm.	Grosser Sprudel.	Cur-brunnen.	Carls-brunnen.
Sodium chloride	29.294	21.824	15.421	9.860
Potassium chloride	1.119	0.497	0.527	0.[illegible]52
Calcium chloride	3.324	1.700	1.034	1.057
Magnesium chloride	0.525	0.440	0.738	0.264
Calcium sulphate	0.035	0.034	0.023	0.227
Calcium carbonate	2.601	2.354	1.146	0.951
Ferrous carbonate	0.048	0.038	0.026	0.014
Total solids	36.946	26.887	18.915	12.385
Temperature (in degrees Fahrenheit)	95.5	89	70.5	59

All of the waters are rich in carbonic acid gas, containing from 579 to 995 c.c. per litre. The weaker wells, the Cur- and Carlsbrunnen, are used, sometimes diluted, for drinking purposes; the stronger ones, sometimes with the addition of a brine containing magnesium bromide, serve for bathing. Baths of all kinds are given, and the water is also administered by inhalation in certain cases.

Of the diseases in the treatment of which the Nauheim waters are recommended, may be mentioned: scrofula, muscular and subacute articular rheumatism, tubercular diseases of the bones and joints, hyperæmic and exudative affections of the uterus and ovaries, spinal irritation, locomotor ataxia, and various forms of paralysis, especially those occurring in childhood, such as anterior poliomyelitis and the paralysis following spinal meningitis. It is, however, for the treatment of the scrofulous and tubercular diseases of children that Nauheim is most frequented. The average number of visitors during the season is between four and five thousand. A course of treatment lasts usually about one month. *T. L. S.*

NAVAL MEDICAL SERVICE. The medical department of the United States Navy is contemporary with the creation of a naval force, which first appears on the Statutes by act of Congress, approved March 27, 1794, and consequently is with the line the oldest of the co-ordinate branches of the naval service. A medical establishment for army and navy, conjointly, under an officer with the title of physician-general, was made the subject of special enactment by Congress, approved March 2, 1799. In the reorganization of the navy, in 1828, the naval medical department prominently participated, and in 1842 the administration of its affairs was placed under the special charge of a Bureau of Medicine and Surgery, of which the chief, appointed for a period of four years from the higher grades of medical officers, received, in 1871, the title of Surgeon-General of the Navy.

In 1855, the medical corps of the navy consisted of sixty-nine surgeons, of whom forty-four had the rank of commander after twelve years service, and twenty-five that of lieutenant; and of seventy-nine passed and other assistant surgeons, the latter ranking next after masters until five years from their entrance into the service, when, upon passing an examination qualifying them for promotion as surgeons, and until a vacancy occurred in that grade, they were termed passed assistant surgeons and ranked next after lieutenants. The corresponding grades of commissioned officers in the line were (1) captain; (2) commander; (3) lieutenant, and (4) master; passed midshipmen and midshipmen being only warranted or steerage officers in contradistinction to cabin and ward-room officers.

During the civil war, the number of surgeons was increased to eighty; that of passed and other assistants varied from one hundred and twenty in 1862, to seventy-five at the close of the war, the extraordinary demand for medical service during that period having been met by the temporary appointment of volunteer officers entitled acting assistant and acting passed assistant surgeons

—these numbering as many as two hundred and fifty one in 1865.

The creation of new grades in the line necessitated corresponding changes in the medical corps, and accordingly, in 1871, the eighty surgeons were subdivided into three grades, fifteen being commissioned as medical directors ranking with captain, fifteen as medical inspectors ranking with commander, and fifty as surgeons, of whom the seniors ranked with lieutenant-commander, and the juniors with lieutenant; assistants were limited to one hundred. In 1882, the assistant surgeons were further reduced in number to ninety, and their rank, on entering the service, was assimilated with that of ensign, a grade required to live in the steerage in the same mess with undergraduates from the Naval Academy.

The relative rank of naval medical officers with those of the line of the navy and with the army, in which service medical officers bear precisely the same commissions and titles as officers of the line, is shown in the following table:

U. S. Army.	U. S. Navy	
All Officers (Line and Medical).	Line.	Medical Corps.
Brigadier General.	Commodore.	Surgeon-General.
Colonel.	Captain.	Medical Director.
Lieutenant-Colonel.	Commander.	Medical Inspector.
Major.	Lieutenant-Commander.	Surgeon (seniors).
Captain.	Lieutenant.	Surgeon (juniors). / Passed Assistant Surgeon (seniors).
First Lieutenant.	Junior Lieutenant (Master).	Passed Assistant Surgeon (juniors).
Second Lieutenant.	Ensign.	Assistant Surgeon.

The military grades of general, lieutenant-general, and major-general, and their naval equivalents, admiral, vice-admiral, and rear-admiral, are not represented in the medical corps of either the United States army or navy; but in the Russian navy medical officers attain the highest military rank known (*General Admiral*, corresponding to field-marshal), and enjoy the same honors and pensions as the line; in the British navy they rise to the rank of vice-admiral and receive the same decorations, etc., as the line, the *Director-General* of the medical department being a K.C.B.; in the Spanish navy they attain the rank of vice-admiral (*Teniente General*), and enjoy, equally with the line, naval honors, rewards, and pensions; in the French navy they attain the rank of rear-admiral (*Contre-Amiral*), the surgeon-in-chief (*Médecin-en-chef*) of a French squadron messing with the commander-in-chief; in the Austrian navy they attain the rank of rear-admiral (*Contre Admiral*), wear the same uniform, enjoy the same privileges, and receive the same retired pay as the line; in the Dutch navy the senior medical officer, *Inspecteur*, has the rank of major-general, and the *Dirigerend Officiers van Gezondheid* that of brigadier; and in the North German navy the senior medical officer, *General Stabs-Arzt*, has the rank of general major.

The relative position of the naval medical officer is, therefore, not as satisfactory as it was half a century ago, when the assistant surgeon entered the ward-room as a commissioned officer, and the senior surgeons attained the next to the highest recognized military rank; while the titular office of "surgeon of the fleet," which, like commodore in the line, was not a distinct grade, but a courtesy distinction of the ranking officer of the fleet or squadron, had no parallel in any other staff corps. To-day the junior medical officer is only assimilated in rank with ensign, a term which has the former significance of the discarded title, midshipman, and by reason of the sharply defined caste distinctions in the navy, he is excluded from the social and official association to which his education and profession entitle him. The result of this degradation of graduates of a learned profession, which all over the world enjoys the most exalted precedence, and of the disparity with the army, in which the assistant surgeon at once begins his military career as first lieutenant, obtaining all the consideration, privileges, and rights of a commissioned officer, has been the cessation of applications for the naval service of the highly educated young men, who were once attracted to it by the prestige of having passed its rigorous entrance examination, and by the opportunity afforded for foreign travel. Hence, in the army, candidates are always in excess of vacancies, while in the navy, even the process of legislative reduction has not been able to fill the corps; and professors and preceptors dissuade the young graduate from appearing before the examining board. In spite of these discouraging influences, the naval medical corps has not lowered its standard to its altered conditions, and it especially deserves a place in a handbook of the medical sciences for two reasons, viz., that, first, in the rigorous requirements for admission, and, second, in the definition of its functions, it illustrates what advocates of higher medicine are aiming to accomplish in the profession at large.

Admission into the medical corps of the navy can only be obtained through a professional examination before the Naval Medical Board, composed of officers of the higher grades. From the beginning this board has assumed to be the sole judge of the qualifications of candidates, the mere possession of the diploma of a medical school not being recognized as even presumptive evidence of professional abilities and acquirements. Inquiry is first made as to whether the candidate has received a liberal education, which is properly considered an indispensable pre-requisite to an intelligent comprehension of the science of medicine. An autobiographical sketch, an essay on some assigned professional topic, and written answers to a series of comprehensive questions in the various departments of medicine, are intended as evidences of such preliminary proficiency, the orthography and punctuation, grammatical construction, form, and manner of expression being as carefully scrutinized as accuracy of statement. An oral examination follows by the several members of the board, in the presence of all, upon every branch of medicine and upon such collateral studies as the candidate may have pursued, with the object, not merely of ascertaining the amount of detailed information he may have acquired by rote, but rather the extent of his intelligent understanding of the fundamental facts and principles which constitute the science of medicine. Finally, extemporaneous chemical and pharmaceutic exercises, the clinical diagnosis and treatment of actual patients in hospital, the adjustment of surgical apparatus and appliances, and the performance of operations upon the cadaver, exhibit his acquaintance with the practical requirements of the healing art, and his fitness to assume its responsibilities under the emergencies, which sometimes place the issue of life or death upon his unaided knowledge and skill.

Manifestly, such a course of examination, written, oral, and practical, adequately determines whether the candidate has received a proper education in medicine, and the examination is only such as should be exacted of every aspirant for a doctor's degree, and such as can be hoped for only when boards of examiners shall be instituted entirely independent of teaching faculties. A second examination, after a lapse of three (formerly five) years is required for passing out of the grade of assistant surgeon preliminary to promotion to that of surgeon. This examination presupposes a wider, practical acquaintance with the various branches of medicine and a familiarity with its current literature. Similarly, in civil life it would be well if the graduate should first receive only a baccalaureate degree (M.B.), and as an incentive to application and study have the M.D. before him as the reward of a second examination five years later. But the interest of the Bureau of Medicine and Surgery in the young naval medical officer does not cease with this final examination. Opportunities for self-improvement are liberally provided, and individual research and investigation are encouraged by the supply of apparatus, instruments, or other facilities required, and by the publication of essays voluntarily contributed, as well as by the requirement of annual statistical, medical, and sanitary reports from every officer in charge of the medical department of a vessel or sta-

tion, embracing the medical topography, climatology, and hygiene of every station or place visited, with all attainable information respecting statistics of disease and its causes, establishments for the care of the sick, charitable institutions, medical colleges, and other matters of professional interest. Again, in civil life, this might be paralleled by the more general employment of young men as salaried attachés of hospitals, dispensaries, asylums, infirmaries, cliniques, and other eleemosynary medical institutions, where, under the supervision of older men, that experience might be acquired which alone justifies any one in accepting the responsibility of human lives, and where similar provisions for professional research might be afforded, which are not possible in a young graduate's meagrely appointed office.

The medical officer of the navy having passed the rigorous examination for admission, is made to understand at the outset of his career that his first duty, as a physician, is to protect the community in which he is established from the ravages of disease; and herein the medical corps of the navy merely exemplifies the real mission of the medical man in every walk in life—to place those who are under his care in the best possible sanitary condition, to jealously guard against the operation of preventable causes of disease, to antagonize the morbific agencies that elude his vigilance, or find access by inscrutable ways, and thus to reduce to a minimum the necessity for therapeutic measures; and finally to use natural agencies for purposes of cure wherever these can replace pharmaceutic administration.

The sanitary supervision of a community like the navy is much simplified by the preliminary physical examination of all the men and boys—adults and adolescents—who enter it, and by their compulsory subjection to regulated habits in food, drink, personal cleanliness, etc. The immature and the very old, the weak and decrepit, women with their special train of ailments, and those predisposed to disease—classes which in civil life outnumber all the rest—are excluded from enlistment. Still, it is within the province, as it is the duty, of the civil practitioner, to inculcate, far more strongly than he does now, hygienic principles, and to enforce restraints, as in preventing the marriage of individuals with transmissible taints.

The following table exhibits the statistics of disease and death in the navy during the past thirteen years:

Year.	Force afloat.				At shore stations.			In naval hospitals.			Aggregate for Navy and Marine Corps, afloat and on shore.					
	Strength, corrected for time.	Number of cases.	Cases per 1,000.	Deaths.	Strength, excluding hospitals.	Cases.	Deaths.	Cases.	Number of deaths.	Deaths per 1,000.	Strength.	Number of cases.	Cases per 1,000.	Number of deaths.	Deaths per 1,000 of strength.	Deaths per 1,000 of cases.
1873	10,371	9,427	909	58	1,592	2,737	11	1,158	59	51	13,121	13,322	1,015	128	9.7	9.6
1874	10,108	10,488	1,037	71	1,301	2,187	9	1,449	80	55	12,858	14,124	1,098	160	12.4	11.3
1875	10,141	8,083	799	53	2,031	2,143	11	979	61	62	13,151	11,205	852	125	9.5	11.1
1876	8,658	8,169	943	42	1,832	2,362	9	918	65	71	11,408	11,449	1,003	116	10.1	10.1
1877	8,609	7,240	841	34	1,922	2,243	7	974	52	53	11,505	10,457	909	93	8.0	8.9
1878	9,007	7,520	835	56	1,844	2,676	8	888	42	47	11,739	11,084	944	106	9.0	9.5
1879	8,869	10,284	1,159	36	1,811	2,582	7	1,117	53	47	11,797	13,983	1,185	96	8.1	6.7
1880	9,003	9,537	1,059	28	1,645	1,858	19	1,015	64	63	11,663	12,923	1,108	111	9.5	8.5
1881	9,546	9,288	973	29	1,307	2,903	19	1,353	49	36	12,196	13,544	1,110	97	7.9	7.1
1882	9,371	8,735	932	44	1,600	2,823	10	1,306	36	27	12,277	12,866	1,047	90	7.3	7.0
1883	9,179	8,550	929	45	1,571	2,482	9	1,228	58	47	11,996	12,260	1,022	112	9.3	9.0
1884	9,959	9,469	950	30	2,007	2,130	10	1,209	42	34	13,175	12,808	972	82	6.2	6.4
1885	9,370	8,593	917	52	1,754	2,437	14	1,245	43	34	12,369	12,275	992	110	8.8	8.9
Average for thirteen years	9,400	8,875	945	44	1,709	2,425	11	1,141	54	47	12,250	12,485	1,019	109	9.0	8.6

The longer lease of life enjoyed in the navy, especially in the force afloat, due to the sanitary prevision indicated, and in spite of the vicissitudes and exposures incident to the seaman's occupation, is illustrated by the following comparison with the mortality statistics of civil life from two localities selected as the most favorably conditioned:

	Number of Persons.	Deaths.	
		Number.	Per 1,000.
Aggregate force afloat, U. S. Navy, 1873-85	112,209	578	5.15
Aggregate strength, U. S. Navy and Marine Corps, afloat and on shore, 1873-85	159,255	1,426	8.95
Population of State of Massachusetts, 1885	1,942,107	38,094	19.61
Aggregate white population, District of Columbia, 1876-85	1,195,510	22,734	19.02
Aggregate negro population, District of Columbia, 1876-85	605,473	21,185	34.90
Population of the United States, Census of 1880	50,155,783	756,893	15.01

While the high death-rate among children under five, and the additional mortality among women from their special maladies, and that among the weak, decrepit, and very old, who are excluded from the navy, explain much of the great excess in civil life, the difference, after every allowance is made, is large enough to illustrate the benefit from the enforcement of those sanitary precautions which are the province of preventive medicine.

The following table exhibits the daily movement of disease in the navy, during the past seven years:

Year.	Aggregate strength of Navy and Marine Corps.	Number sick daily.				Among every 1,000 officers and men in Navy and Marine Corps.					
		Afloat.	At shore stations.	In naval hospitals.	Total.	Afloat.		On shore.		In hospital.	Total number of sick daily per M. of strength.
						Number.	Sick.	Number.	Sick.		
1879	11,797	244	61	211	516	752	20	230	7	18	45
1880	11,663	225	48	216	489	772	19	210	6	18	43
1881	12,196	201	52	204	457	782	16	202	8	16	40
1882	12,277	216	56	179	451	763	17	222	7	15	39
1883	11,996	191	46	190	427	765	15	219	6	16	37
1884	13,175	214	41	190	445	755	16	231	4	14	34
1885	12,369	188	43	176	407	757	15	229	5	14	34
Average for seven years.	12,210	211	50	195	456	764	17	220	6	16	39

Naval medical statistics, like all others, are defective in many respects, as for example, in the absence of a precise record of the shifting populations of both shore and foreign stations, and their correction for time to a uniform basis for calculating per millage rates; but, on the other hand, their record of the number of actual occurrences of sickness supplies what is a present serious

defect in vital statistics in civil life. Mere death-rates are not an exact measure of the perverted vital condition of a community through sickness, since the progress of medical science and improved medical art have largely diminished the proportion of fatal results where the causes of disease are still operative. What is really required is an exhibit of the actual number of cases of disease, especially of those due to preventable causes, and this information both army and naval medical returns accurately supply.

It must be borne in mind that many of the cases recorded in the navy are never brought to a physician's notice in civil life, but are subjects of domestic treatment, if of any, or fall into the hands of apothecaries and irregular practitioners; but the fact that the army of physicians, charlatans, and prescribing apothecaries find abundant means of support, is sufficient evidence of the amount of medical material for tabulation.

The naval medical service, in common with that of the army, therefore, demonstrates, first, the possibility of excluding incompetents from the ranks of the profession, by rigorous inquiry as to the qualifications of candidates; second, the practical results of the exercise of that higher office of the medical man—the prevention of disease; third, the proper scope and object of vital statistics in their relation to the science of medicine.

Albert L. Gihon.

NECK, SURGICAL ANATOMY OF. By the neck we usually mean the space between the occipital bone and lower jaw, above, and the upper aperture of the thorax, below. For convenience of description it is advisable to divide the neck into regions, viz., two lateral, anterior median, and posterior.

The *lateral* region represents a quadrilateral which is divided diagonally by the great sterno-mastoid muscle into two triangles, the anterior (carotid) and posterior. Each of these is again subdivided into two by the omo-hyoid muscle. The anterior triangle is subdivided into a superior and inferior carotid triangle, and the posterior into an occipital and subclavian triangle.

The *anterior median* region is divided into two spaces by the hyoid bone, the upper being called the supra-hyoid or submaxillary, and the lower the infrahyoid or hyosternal region.

The *submaxillary* region is bounded posteriorly by the posterior belly of the digastric and stylo-hyoid muscles, and contains the submaxillary gland.

The *posterior region* includes the portion commonly known as the nape of the neck.

Surface Anatomy.—The outline of the neck varies much in different people; in stout individuals it is round and full, and the various landmarks are not easily distinguished; in thin people, on the other hand, every landmark stands out prominently, and can be made out by even the most inexperienced. The neck is, as a rule, fuller and rounder in women and children, and the *pomum Adami* is less marked. In muscular males the prominences are well seen; in old people who are thin the sterno-mastoid muscles and superficial veins stand out well, as does also the internal border of the platysma myoides.

Bony Points.—The most important bony point, and one of those most easily felt, is the hyoid bone, which is in the median line, a finger's breadth above the thyroid cartilage. It is opposite the fourth cervical vertebra. The cricoid cartilage is opposite the sixth cervical. Below and in front of the mastoid process, and behind and above the angle of the lower jaw, the transverse process of the atlas can be felt; in the posterior region in the middle line is a depression formed by the complexus and trapezius muscles of each side; here can be indistinctly made out the third, fourth, fifth, and sixth cervical spines, the seventh can be easily felt, and also the spines of the first two dorsal vertebræ. These become more prominent when the head is bent forward; occasionally, when the spine of the sixth cervical vertebra is well developed, it is quite as prominent as the seventh. The transverse process of the sixth cervical vertebra can be felt on deep pressure opposite the cricoid cartilage, in the course of the carotid vessels. This is called the "carotid tubercle," and here the carotid may be easily compressed against it.

Anterior or Median Region.—In the receding angle below the chin is the hyoid bone; its course can be easily felt in the fattest necks, and it divides the anterior part of the neck into the suprahyoid and infrahyoid regions. In the median line of the suprahyoid region, the anterior bellies of the digastric muscles cause a slight convexity; on the outer side of each anterior belly of the digastric muscle is felt the submaxillary gland lying on the mylo-hyoid muscle, which helps to form the floor of the mouth. This region is commonly cut into in self inflicted wounds of the throat. About half an inch below the hyoid bone is the prominent thyroid cartilage (pomum Adami). This cartilage is prominent in deep-voiced men and people with thin necks, but in women and children is not so

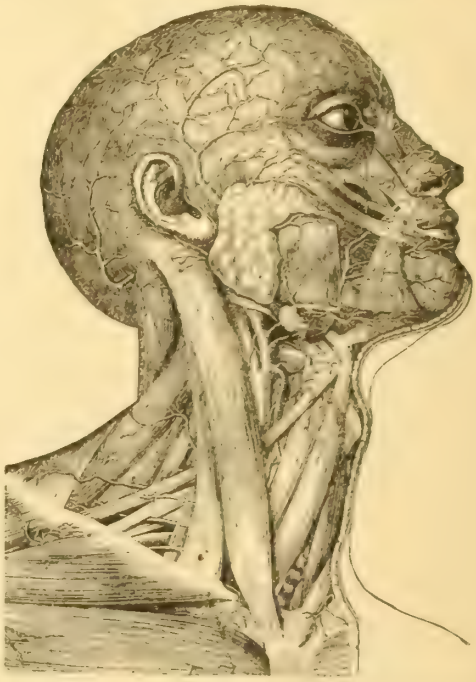

Fig. 2429.—Dissection of the Neck, showing the Triangles and their Contents. (Tiedemann.)

distinctly seen; the notch at its upper border can be easily felt, and is commonly situated to one side of the median line. The superior cornua of the thyroid cartilage can be traced with the finger. The space between the thyroid cartilage and the hyoid bone is called the thyro-hyoid space, a membrane connecting these two structures; this membrane is covered by the muscles going to the hyoid bone from below, and is pierced by the superior laryngeal nerve and artery of each side. A cut made through the thyro-hyoidean space would sever the lower part of the epiglottis. The rima glottidis is opposite the middle of the thyroid cartilage. Below this cartilage the finger sinks into a slight depression, the crico-thyroid space; this is the space in which the operation of laryngotomy is performed, the opening here being well below the vocal cords. Across this space ramify two small vessels, the crico-thyroid branches of the superior thyroid arteries. The next landmark of interest is the cricoid cartilage; it is a guide to many operations on the neck and air-passages, and can be distinguished in the youngest and fattest neck. The cricoid cartilage is opposite the sixth cervical vertebra, and the narrowest part of the gullet is behind it; at this point foreign bodies are most likely to be arrested. The omohyoid muscle crosses the carotid vessels on a line with the cricoid cartilage, immediately above

which line is the point usually selected for tying the common carotid artery. The middle cervical ganglion of the sympathetic is also on a line with this cartilage, and a little below and outside of it is the point where the vertebral artery enters the transverse process of the sixth cervical vertebra.

Below the cricoid cartilage the finger passes on to the trachea, the separate rings of which cannot be easily felt, because they are covered by the isthmus of the thyroid gland above, and below the trachea recedes from the surface. At the upper border of the sternum the trachea is one inch and a half from the surface. The isthmus of the thyroid crosses the second and third rings of the trachea.

In front of the trachea, below the isthmus, lie the inferior thyroid veins, which give so much trouble in tracheotomy. Occasionally an artery is found lying upon the trachea, on its way to the thyroid gland; it is called the thyroidea ima and generally arises from the innominate. The episternal notch is felt at the top of the sternum, and is opposite the second dorsal vertebra.

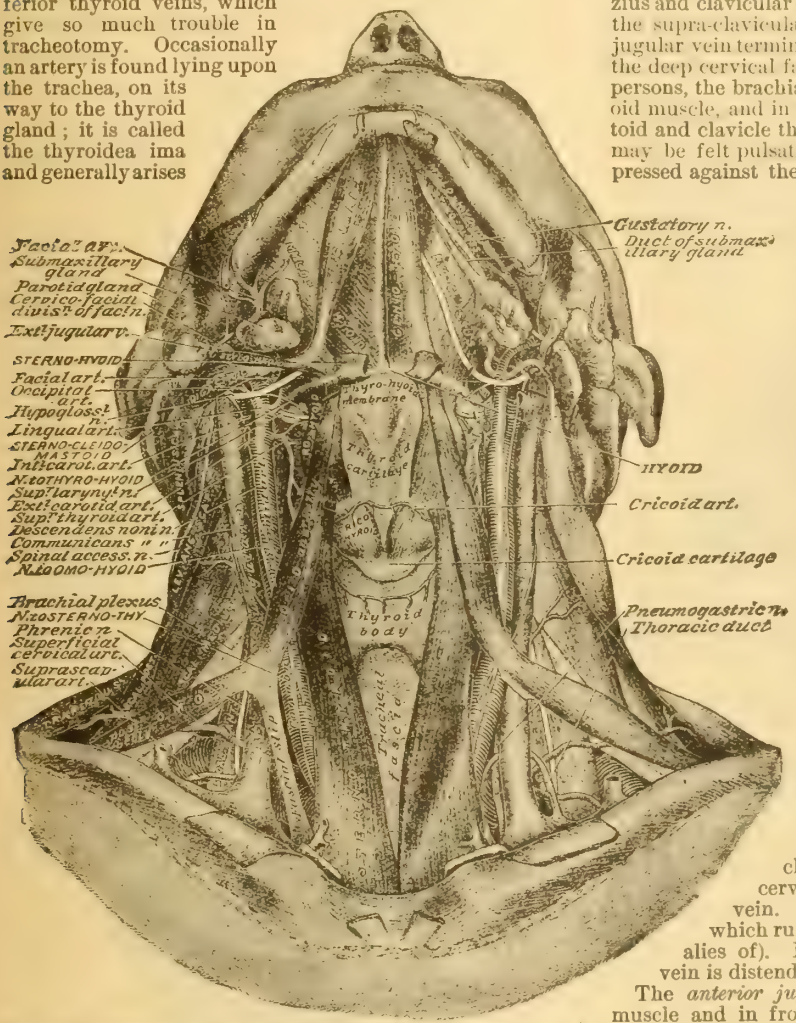

FIG. 2430.—Dissection of Anterior Part of Neck. (From Weisse's Anatomy.)

Lateral Region.—The sterno-mastoid muscle is the prominent landmark in this region; in thin subjects, especially, it is well seen, and stands out distinctly when the face is turned to the opposite shoulder. The inner border, which covers the carotid artery, is more strongly marked than the posterior, which is thin, only the lower portion showing through the skin. The sternal tendons are well seen in nearly everybody, the depression between them being named the supra-sternal fossa. In some necks this fossa is absent, owing to the space being filled with fat. The space between the sternal and clavicular portions of the sterno-mastoid can usually be made out; in thin necks it is well marked. The internal jugular vein and carotid artery lie behind this space; deeper down still, we have the apex of the lung, which sometimes rises an inch and a half above the clavicle.

The sterno-clavicular articulation is an important landmark; immediately behind it, on the left side, is the common carotid artery and the division of the innominate; on the right, it is opposite the point where the internal jugular joins the subclavian vein to form the innominate. The division of the innominate artery in children is higher up than the articulation; in some cases it divides in front of the trachea (see Arteries, Anomalies of).

The depression above the clavicle, between the trapezius and clavicular origin of the sterno-mastoid, is called the supra-clavicular fossa. In this fossa the external jugular vein terminates in the subclavian, after piercing the deep cervical fascia. Here also may be felt, in thin persons, the brachial plexus of nerves and the omohyoid muscle, and in the angle formed by the sterno-mastoid and clavicle the third part of the subclavian artery may be felt pulsating. At this point it can be compressed against the first rib. The central point of the greatest convexity of the clavicle is opposite the third portion of the subclavian artery. This is a more certain landmark than the muscle, the extent of attachment of which to the clavicle varies considerably.

The posterior border of the sterno-mastoid corresponds pretty closely to the outer border of the scalenus anticus muscle; this point should be borne in mind in tying the subclavian artery.

Behind the sterno-mastoid the chain of lymphatic glands, when enlarged, can be easily felt.

The posterior belly of the digastric muscle corresponds to a line drawn from the mastoid process to the body of the hyoid bone. When the chin is extended a prominent fold of cervical fascia can be felt going from the angle of the lower jaw, downward and outward.

The position of the tonsil corresponds externally to the angle of the jaw.

VEINS (SURFACE MARKING OF).—The most important of these is the *external jugular*, which can always be seen. Its course is marked out by a line drawn from the angle of the jaw to the middle of the clavicle, at which point it pierces the deep cervical fascia to join the subclavian vein. It is occasionally joined by a vein which runs over the clavicle (see Veins, Anomalies of). By pressing above the clavicle the vein is distended, and its course is easily traced.

The *anterior jugular* vein lies on the sterno-hyoid muscle and in front of the inner border of the sterno-mastoid. When the external jugular is small this vein attains considerable size.

The surface marking of the *internal jugular* corresponds to a line drawn immediately external to the line of the artery. The *facial vein* runs from the anterior border of the masseter muscle downward and backward, and joins the internal jugular opposite the upper border of the thyroid cartilage.

The *middle thyroid vein* crosses the carotid artery opposite the cricoid cartilage.

ARTERIES (SURFACE MARKING OF).—The *carotid* artery corresponds to a line drawn from the sterno-clavicular articulation to a point midway between the mastoid process and angle of the jaw. The *common carotid* reaches as high as the upper border of the thyroid carti-

lage. It can be compressed against the sixth cervical transverse process (" carotid tubercle "), which is opposite the cricoid cartilage. The *superior thyroid* artery comes off from the external carotid a little above the upper border of the thyroid cartilage. The *lingual* artery runs forward from the external carotid to the upper border of the great cornu of the hyoid bone, to which it is parallel. The hypoglossal nerve lies above the artery. The course of the *facial* artery in the neck corresponds to a line drawn from the tip of the great cornu of the hyoid bone to the outer border of the masseter muscle.

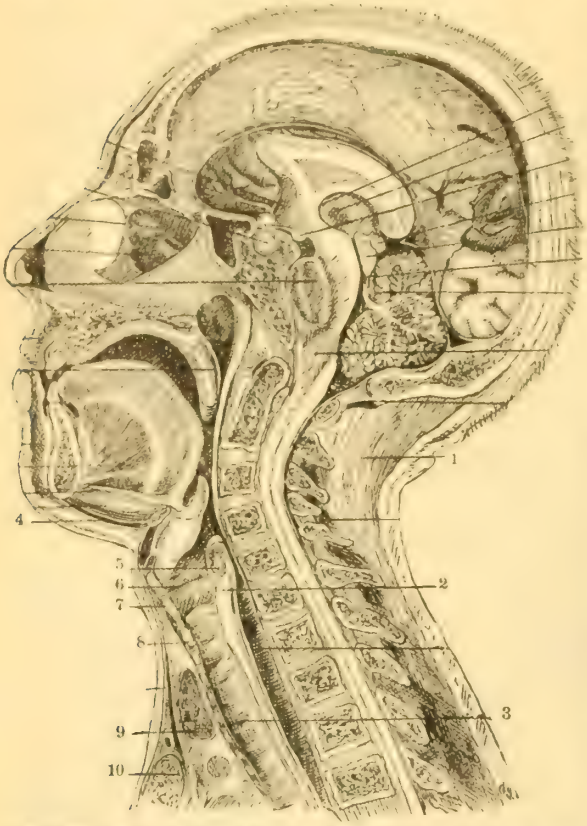

Fig. 2431.—Vertical Median Section of the Head and Neck. 1, Ligamentum nuchæ; 2, cricoid cartilage; 3, trachea; 4, hyoid bone; 5, mus. arytenoideus; 6, ventricle of larynx; 7, thyroid cartilage; 8, cricoid cartilage; 9, thyroid body; 10, sternum. (After Braune.)

The *occipital* arteries can be felt pulsating immediately below and a little in front of the tip of the mastoid process.

Nerves (Surface Marking of).—The *spinal accessory* nerve passes beneath the anterior border of the sterno-mastoid muscle an inch below the tip of the mastoid process, and emerges from the posterior border at a point on a level with the upper border of the thyroid cartilage; it then crosses the posterior triangle obliquely and enters the trapezius muscle on a level with the sixth or seventh cervical spines.

The *phrenic* nerve commences in the neck about the level of the hyoid bone, and runs obliquely downward over the scalenus anticus to its inner edge. In the neck the phrenic nerve is covered by the sterno-mastoid.

The *superficial cervical* nerves all emerge at a point corresponding to the middle of the posterior border of the sterno-mastoid. The *great auricular* crosses the sterno-mastoid on its way up to the ear; the *lesser occipital* runs along the posterior border of the sterno-mastoid; the *superficial cervical* crosses the sterno-mastoid at right angles and reaches the middle of the neck, and lines drawn from the point of emergence to the sternum, middle of the clavicle, and the acromion would mark the course of the *supra-sternal*, *supra-clavicular*, and *supra-acromial* nerves.

The cutaneous branches of the cervical plexus are widely distributed, supplying the ear, back of scalp, cheek, parotid gland, side and front of neck, and upper part of chest and shoulder.

The facial nerve sends a branch to the neck, which supplies the part of the neck immediately below the lower jaw.

Topographical Anatomy.—The skin over the anterior and lateral regions of the neck is thin and lax, and in plastic operations is of great value in making flaps. The platysma is closely connected with the skin of this part of the neck. There is frequently some transverse wrinkling of the skin above the hyoid bone, and in this region in fat people there is much fat, giving rise to what is called a double chin; here also the sebaceous follicles are very abundant. In adult males this part is covered with beard.

The skin of the posterior region is very thick and adheres closely to the deeper structures; this is due to the large number of short fibrous connections between the skin and fascia. Carbuncles and boils frequently occur here and cause great pain, owing to the density of the parts and their free nerve-supply.

The *nape* of the neck is often the seat of pustular and vesicular eruptions, which are due almost invariably, when localized in this part, to the presence of pediculi, these parasites finding a safe habitat in the thick hair under the prominent portion of the occipital bone. The glands in this region are frequently enlarged in sympathy with eruptions of the hairy scalp. The nape of the neck was the favorite site, in olden times, for the application of setons and issues.

Fatty tumors are often seen at the lower part of this region.

Cervical Fascia.—It is the custom to divide the deep fascia of the neck into *superficial* and *deep* processes. The superficial fascia invests all the muscles, with the exception of the platysma; and some of the veins, as the external jugular, are also superficial to it. It is attached posteriorly to the spinous processes of the cervical vertebræ and ligamentum nuchæ; passing forward it splits to enclose the trapezius and then crosses the posterior triangle; at the posterior border of the sterno-mastoid the fascia divides into two layers which enclose that muscle, these layers unite at the anterior border of the muscle, and the fascia passes on to the middle line of the neck, where it is continuous with that of the opposite side. It covers the anterior triangle, being attached above to the lower jaw. In the posterior triangle the fascia is attached below to the clavicle and above to the mastoid process and the superior curved line of the occipital bone; in this tri-

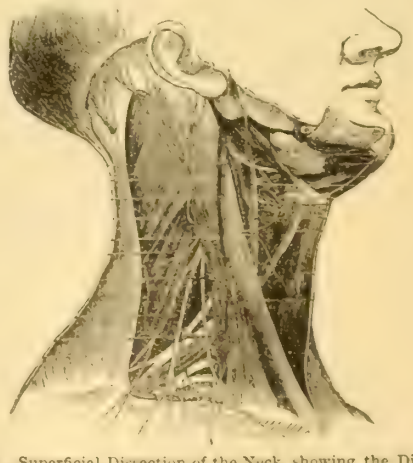

Fig. 2432.—Superficial Dissection of the Neck, showing the Distribution of the Branches of the Superficial Cervical Plexus of Nerves. (Heath.)

angle it is pierced by the external jugular vein and some of the superficial cervical nerves. In the anterior triangle the fascia is attached above to the body of the lower jaw, and continues backward and upward over the parotid gland to be attached to the zygoma. It sends a process (the stylo-maxillary ligament) between the parotid and submaxillary glands. In front the fascia is attached to the hyoid bone and covers the thyroid gland, below which it splits into two layers; the deeper covers the sterno-hyoid and sterno-thyroid muscles, and is attached below to the posterior edge of the first piece of the sternum, behind the sterno-clavicular joint; the superficial and thinner layer passes down over the sterno-mastoid muscles, and is attached to the anterior edge of the manubrium and interclavicular ligament. The space between these two layers is filled with cellular tissue and fat, and sometimes a small gland is found here. In this compartment is also found the sternal head of the sterno-mastoid and the anterior jugular vein. In tenotomy of the sterno-mastoid this space must be opened, and the vein is avoided by keeping the knife close to the tendon of the muscle.

This space is also cut through in performing the operation of tracheotomy, and air is sometimes driven at every inspiration into the cellular tissue beneath the deep layer, an occurrence which complicates the operation exceedingly. The process of fascia covering the posterior belly

Fig. 2433.—Transverse Section of the Neck through the Fifth Cervical Vertebra, showing Cervical Fascia. (Braune.)

of the omohyoid and binding it down to the clavicle and first rib, is continuous with the fascia covering the depressors of the hyoid bone.

The deeper processes of cervical fascia are important; one comes off from the anterior border of the sterno-mastoid and forms a sheath which encloses the carotid artery, jugular vein, and pneumogastric nerve. The vein is separated from the artery by a thin septum of fascia.

A process of fascia also invests the thyroid body, passes behind the depressors of the hyoid bone, and lies in front of the trachea and deep vessels of the neck; below, this layer is continuous with the fibrous pericardium.

The *pre-vertebral* fascia is a layer which descends on the pre-vertebral muscles, separating them from the pharynx and œsophagus; laterally it joins the carotid sheath and then proceeds outward covering the scalene muscles, brachial plexus of nerves, and subclavian vessels, becoming continuous with the axillary sheath. It is also connected with the costo-coracoid membrane (see Axilla).

Although the cervical fascia influences to a certain extent the growth of tumors and collections of matter, this influence has been much exaggerated, and tumors grow and matter collects and distributes itself often quite irrespective of this fascia.

Pus in front of the trachea would tend to gravitate into the anterior mediastinum and on the side of the neck might perforate the apex of the pleural sac. An abscess in front of the vertebræ would lie beneath the pre-vertebral fascia, and if it did not burst into the gullet, might extend laterally and present outside the sterno-mastoid, or descend to the posterior mediastinum. In some cases these collections of pus have been known, after reaching the posterior triangle of the neck, to follow the course of the brachial plexus and present in the axilla. Pus pent up between the layers of the cervical fascia has destroyed portions of not only the jugular vein, but the carotid artery, and when the abscess cavity was opened the patient has died of hæmorrhage from these vessels. Dr. S. W. Gross (*American Jour. of the Medical Sciences*, April, 1871) has collected twelve cases of ulceration of the jugular veins, with hæmorrhage into the sacs of closed abscesses, or into abscesses several days after their contents have been evacuated, or into acute or chronic ulcers. The majority of cases were in children who had cellulitis of the neck following scarlet fever—all the cases proved fatal.

Dr. Erichsen (*St. Petersburg Med. Woch.*, December, 1877) reports a case of suppurative angina which broke of itself, and several days after a profuse and fatal hæmorrhage occurred. The autopsy revealed ulceration of the internal carotid artery. In such cases the lesson to be learned is to prevent the destructive effects of diffuse cellulitis by early and free incision, and if hæmorrhage does occur, not to rely exclusively on plugging, but to ligature the affected vessel.

In opening abscesses on the neck, there is some danger of wounding some of the great vessels if a too free incision be made with the knife, the vessels being pushed out of their normal position by the abscess; their exact course is difficult to determine; in such cases at first the skin only should be incised; after this the knife should be laid aside and a director should be pushed through the fascia, when pus runs along the groove of the director, a pair of dressing forceps should be introduced, opened in the abscess cavity, and withdrawn open. This method has the advantage of being perfectly safe, and is especially adapted for opening deep-seated abscesses. It is known as Hilton's method.

Arteries of the Neck.—The two large arterial trunks which are seen in the neck are the *carotid*, which lies in the anterior triangle, and the *subclavian*, which lies in the lower part of the posterior triangle (subclavian triangle).

The *carotid* is included in a sheath of deep cervical fascia with the internal jugular vein and pneumogastric nerve. The vein lies to its outer side, and in the living subject overlaps the artery at the lower end and especially on the left side. To the inner side of the artery lie the trachea and œsophagus, larynx and pharynx, and low down the recurrent laryngeal nerve. The thyroid gland also lies to its inner side. The vagus nerve lies to the outer side and posteriorly above, and rather more in front below.

Lying on the sheath of the vessels is the descendens noni nerve. The great sterno-mastoid muscle covers not only the common, but also the internal and external carotid arteries. In the undissected subject it is impossible to puncture the common carotid from the side of the neck without piercing the sterno-mastoid muscle (Richet). This fact is not sufficiently dwelt on in anatomical works, the descriptions given being applicable to dissected subjects only. The omohyoid muscle crosses the artery and vein obliquely and on a line with the cricoid cartilage. The most important structures behind the artery are the sympathetic trunk, the inferior thyroid artery, and the recurrent laryngeal nerve. The common carotid normally gives off no branches in its course. It divides into external and internal carotid opposite the upper border of the thyroid cartilage. The right and left common carotid arteries are so similar in their course in the neck that one description will answer for both. The left, however, it is well to bear in mind, arises from the arch of the aorta, and is somewhat longer than the right, which arises from the innominate opposite the right sterno-clavicular articulation. The right common carotid is generally larger and not so deeply placed in the neck as the left; it is also further away from the trachea.

As the vessels ascend the neck they become more

superficial, and having a direction somewhat backward, get farther apart as they reach their termination. The surface marking of the carotid has already been described.

The artery may be easily compressed against the transverse process of the sixth cervical vertebra.

Ligature of the Common Carotid.—A ligature may be applied to any part of the artery, except near its origin or termination. The usual point of ligature is either immediately above or below the omohyoid muscle. It is usually ligatured above the omohyoid, as here the artery is more superficial, and the operation is, in consequence, easier. An incision should be made along the inner border of the sterno-mastoid muscle, and the parts carefully divided until the sheath of the vessels is reached. The operation is much facilitated by drawing the sterno-mastoid outward and (if the superior operation be chosen) pulling inward the omohyoid. Should any veins or small branches of the superior thyroid artery come in the

Fig. 2431. View of the Common Carotid and Subclavian Arteries, with the Origin of their Branches and their Relations. (R. Quain.)

way, they should be divided between two ligatures. The sheath of the vessels should be opened on its inner side, so as to avoid the jugular vein, and the descendens noni nerve should be held aside to avoid injury. The aneurism-needle with the ligature should be passed from without inward; in this way the vein and vagus nerve are most easily avoided.

The lower operation is the more difficult one, for, to expose the sheath of the vessels it is often necessary to divide some fibres of the muscles covering it. Again, the vein, if large, overlaps the artery; this renders the passing of the aneurism-needle a proceeding of some difficulty. On the left side the internal jugular vein is much closer to the artery than on the right, and so the difficulty of passing a ligature around the artery is much increased. Ligature of the carotid is performed for wounds of the vessel or some of its branches, also for aneurism. It has been ligatured for pulsating orbital tumor. Mr. W. Rivington (*British Medical Journal*, October, 1885) records an interesting case of a boy aged nine years, who swallowed a fish-bone; this was followed by pyrexia, stiff neck, salivation, and a tender lump on the left side of the neck opposite the cricoid cartilage. Three days later the boy had two severe attacks of hæmorrhage from the mouth. Wound of the carotid was diagnosed, and the artery cut down upon and ligatured. The fish-bone was found in the centre of a clot, and it had ulcerated into the artery. The patient died of abscess of the brain ten days after the operation. A common site of carotid aneurism is at the bifurcation of the common carotid, and the treatment is ligature of the vessel below. In aneurism at the root of the neck the carotid has been ligatured with success above the tumor. Ligature at the distal side of an aneurism was first proposed by Brasdor, and practised by Wardrop. The treatment of aneurism of the arch of the aorta or innominate artery by simultaneous ligature of the carotid and subclavian arteries has been attended in a few cases with benefit.

Aneurism at the root of the neck frequently gives rise to "pressure symptoms." When the great venous trunks are compressed there is œdema and lividity, not only of the side of the face and neck, but also of the upper extremity of the same side. Not infrequently cough is produced by pressure on the recurrent laryngeal nerve, and if the pressure be great, then paralysis of the vocal cords of that side will ensue, and cause a marked alteration of the voice. Dilatation of the pupil may also occur from pressure on the sympathetic trunk.

When the common carotid reaches the upper part of the larynx, it divides into two trunks, one of which, the *external*, gives off a number of branches, and is distributed to the superficial parts of the head and face and the tongue; the other, the *internal*, furnishes blood to the brain and eye. As a rule, the internal carotid has the deeper course, and lies behind the external, but not infrequently the two arteries lie side by side for some distance, the internal lying more posteriorly, and being recognized by the accompanying pneumogastric nerve. The two vessels are separated by the styloid process and stylo-hyoid ligament, also the stylo-glossus and stylo-pharyngeus muscles and glosso-pharyngeal nerve. The external trunk has two muscles and a nerve in relation to it anteriorly, viz., the digastric and stylo-hyoid muscles, and the hypoglossal nerve which hooks round one of its branches, the occipital. After passing behind the angle of the lower jaw the external carotid becomes imbedded in the parotid gland.

Ligature of the external carotid is not a very easy operation owing to the number of branches given off from it, and the large venous trunks which lie over the lower portion may much increase the difficulties. The artery is reached by an incision in the line of the vessel, having its midpoint about the level of the hyoid bone. It is usually ligatured immediately below the digastric. It occasionally requires ligature in the course of operations for the removal of tumors about the angle of the jaw and neck.

Branches of External Carotid.—The most important branches in the neck are the superior thyroid, lingual, and the cervical portion of the occipital and facial.

The *superior thyroid* arises near the origin of the main vessel and curves downward, forward, and inward, beneath the depressors of the hyoid bone. It is distributed to the upper part of the thyroid gland, and can be readily exposed by an incision between the omohyoid and sterno-mastoid muscles. It sends a branch along the crico-thyroid membrane which is sometimes wounded in the operation of laryngotomy. The superior thyroid artery has lately been tied with success for the purpose of arresting the growth of an enlarging thyroid body.

The *lingual* artery arises from the external carotid nearly opposite the great cornu of the hyoid bone (it may, however, arise in common with the superior thyroid and cross the hyoid bone). It runs above and parallel to the great cornu and beneath the hyoglossus muscle. It is frequently necessary to ligature the lingual previous to extirpation of the tongue.

In ligaturing this vessel the one guide which the operator must rely on is the great cornu of the hyoid bone—it

can always be felt and its relation to the artery is always constant. The best place to expose the artery is immediately above the great cornu. Some authorities advise ligature of the artery near its origin from the carotid, but here, owing to the large veins which cover it, the operation is more difficult, and besides we have no absolute guide as to the exact point of origin of the artery, which frequently varies. On the other hand, the relation of the

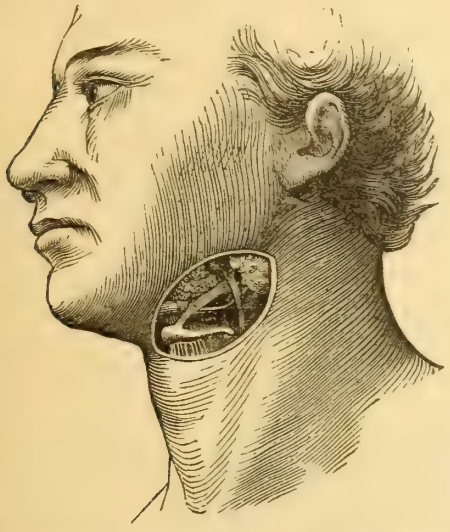

Fig. 2435.—Dissection of Lingual Artery, showing its Relation to the Hyoid Bone and Hypoglossal Nerve. (Roser.)

vessel to the great cornu of the hyoid bone is nearly always constant. The incision should be a curved one, and should extend from near the symphysis menti to near the angle of the lower jaw. The convexity of the curve should be downward, and its lowest point ought to reach the hyoid bone. After dividing the skin, platysma, and deep fascia, the tendon of the digastric muscle should be searched for, and in the angle the tendon forms with the hyoid bone the artery will be found running beneath the hyoglossus muscle; the hypoglossal nerve is seen running over this muscle. If the submaxillary gland cover the parts, it should be held aside with hooks. After carefully dividing the hyoglossus muscle the artery will be felt pulsating at the bottom of the wound. If the incision be carried too far back the facial vein may be wounded.

When it is necessary to remove the submaxillary gland the facial artery must be ligatured. The operation presents no difficulties and requires no special description.

The *subclavian artery* is, surgically, a very important vessel. The left subclavian lies deeper than the right and arises directly from the arch of the aorta, while the right is one of the terminal branches of the innominate and commences opposite the right sterno-clavicular articulation. Each artery curves upward into the neck under the anterior scalenus muscle, and then descends into the subclavian triangle under the clavicle and over the first rib. The subclavian vein lies in front and somewhat below the artery, from which it is separated by the anterior scalenus.

The artery is divided into three portions by the scalenus anticus muscle, viz., first, portion internal to the muscle; second, portion beneath the muscle; and, third, portion external to the muscle reaching to the lower border of the first rib. Surgically, the third portion is most important. The external jugular vein crosses the artery, and the sterno-mastoid and the deep fascia which binds down the omohyoid muscle to the clavicle are in front of it; the brachial plexus of nerves lies above and to the outside of the third portion of the artery. Posteriorly the artery lies on the pleura, scalenus medius, and finally rests on the first rib. The third portion of the artery can be felt pulsating above the clavicle in the supraclavicular fossa, and here it may be readily compressed against the first rib with the thumb or the handle of an old-fashioned door-key wrapped in lint. The direction of the pressure should be vertical to the axis of the body; before attempting compression the shoulder should be lowered as much as possible. In compressing this vessel pain is sometimes caused by pressing on the lowest cord of the brachial plexus, which usually lies behind the artery; this may be easily avoided by rolling the nerve away from the artery, and then the proceeding is quite painless.

Some individuals (the writer among them) can arrest the pulse at the wrist by forcibly carrying the shoulder downward and backward. In this case the artery is compressed against the first rib by the subclavius muscle and clavicle.

Ligature of the subclavian is, as a rule, confined to the third portion, or that part lying in the supra-clavicular space between the sterno-mastoid and trapezius muscles; the other portions are so deeply placed, so thickly studded with branches, and so closely connected with such important structures as the phrenic and vagus nerves, the junction of the internal jugular and subclavian veins, and, on the left side, with the thoracic duct, that ligature is rarely attempted. On the right side it is possible to ligature the vessel between the common carotid and the internal jugular vein.

The third portion of the vessel is comparatively superficial, being covered above the clavicle by no other soft parts than the skin, fascia, and fat. In at least fifty per cent. of subjects it is branchless, and when a branch is given off from the third portion it is almost invariably the posterior scapular.

To reach the artery an incision is made between the sterno-mastoid and trapezius. The skin should be drawn down and the first incision should be made upon the clavicle to avoid wounding the external jugular, which pierces the deep fascia immediately above the clavicle. The vein should be held aside, or, better still, divided between two ligatures, and the deep fascia attached to the clavicle cut through; the finger should then be introduced and the scalene tubercle of the first rib searched for; this tubercle is usually found by following down the scalenus anticus muscle, which runs in the direction of the posterior edge of the sterno-mastoid. Having made

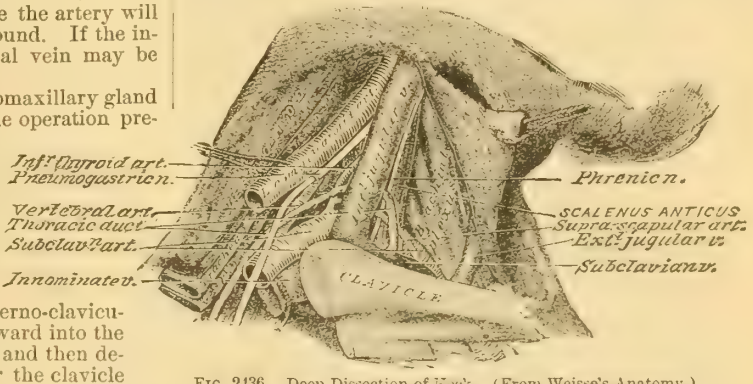

Fig. 2436.—Deep Dissection of Neck. (From Weisse's Anatomy.)

out the scalene tubercle, the artery will be felt pulsating beneath the finger immediately outside the scalenus anticus muscle. The aneurism-needle should be introduced from below upward to avoid the vein; it must hug the artery closely so that the lowest cord of the brachial plexus may not be included.

The operation is performed for aneurism of the axillary artery, and also of the innominate. In the latter case the common carotid is also tied. In axillary aneurism the operation is much complicated by the great distention of the veins and the great elevation of the clavicle.

Branches of the Subclavian.—The subclavian is rich in branches which are distributed in three different directions, viz., the vertebral and inferior thyroid, upward; the transversus colli and transversus humeri, outward; and the internal mammary and superior intercostal, downward. Most of the branches arise internal to the scalenus

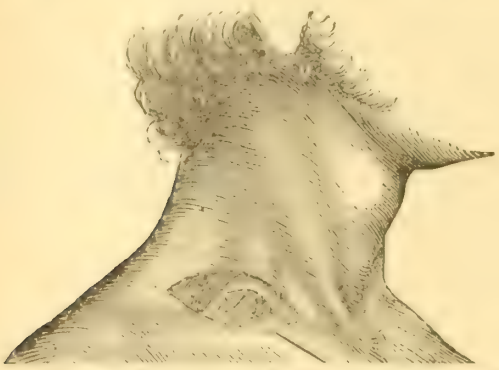

Fig. 2437.—Showing Line of Incision and Parts Exposed in Ligature of the Third Part of the Subclavian Artery. (Modified from Roser.)

anticus; three of them, the transversus colli, transversus humeri, and inferior thyroid arise from a single trunk, the thyroid axis. The posterior scapular is frequently given off from the third part of the artery in place of from the transversus colli. The branches of the subclavian artery are subject to innumerable variations both as to their number and origin (see Arteries, Anomalies of). When the subclavian is ligatured, there being free anastomosis between its branches and those of the axillary artery, the nutrition of the arm is not interfered with.

The *vertebral artery*, which is the largest branch of the subclavian, arises from the upper and posterior part of the first portion, and ascends to enter the transverse process of the sixth cervical vertebra; after piercing the transverse process of the axis it makes a remarkable curve (Fig. 2438, 5) outward and upward to reach the foramen in the transverse process of the atlas, and bending backward, runs in the deep groove on the upper surface of the atlas.

Immediately above the clavicle this vessel lies very deeply between the scalenus anticus and longus colli muscles. It has frequently been ligatured here for the relief of epilepsy; the operation is a difficult one, owing to the many important structures in close relation with the vessel. An incision is made along the posterior border of the sterno-mastoid muscle immediately above the clavicle, the transverse process of the sixth cervical vertebra (carotid tubercle) is now searched for, and the artery is found lying between the scalene and longus colli muscles.

Drs. Bright and Ramskill state that disease of the vertebral artery, immediately before it enters the skull, may lead to pain at the back of the head. The fact that the artery is here in close relation with the suboccipital nerve, which communicates with the great occipital nerve, may explain this symptom (Treves).

The vertebral artery is sometimes wounded by stabs in the neck; not a few cases are reported where the artery was injured by stabs below the mastoid process. Dr. King (*Lancet*, November, 1885) records a case of injury of this artery in a young man, aged twenty-five, due to a deep wound below the left mastoid process; there was severe bleeding, so the wound was enlarged and the transverse process of a cervical vertebra was found broken; the finger placed between two transverse processes stopped the hæmorrhage; the wound was plugged with strips of oiled lint, and in four weeks the patient had perfectly recovered. The plug was removed on the fourth day.

Hæmorrhage from wounds of the vertebral artery between two transverse processes is difficult to arrest; wooden plugs have sometimes succeeded; occasionally the artery has been successfully tied by snipping away the transverse process and applying a ligature. If this cannot be done the bleeding vessel may be secured by artery forceps, which should be left in the wound.

Traumatic aneurisms of the vertebral artery may occur after a stab in the neck; the writer on one occasion saw this follow a wound of the vessel between the second and third cervical transverse processes. These aneurisms are commonly mistaken for aneurism of one of the branches of the carotid, as, for instance, the occipital, and the common carotid has been tied on this supposition, without avail, of course. The mistake has arisen from the surgeon finding that pulsation in the aneurism ceased on compressing the carotid in the neck. Of course, if it is compressed below the "carotid tubercle," the circulation in the vertebral is arrested as well as in the carotid; and even if pressure is applied at this point, the vertebral may be compressed, for it frequently fails to enter the foramen in the transverse process of the sixth cervical vertebra.

The ligature placed on the carotid should be first tightened, and, if this arrests the pulsations in the aneurism, the ligation may be completed; but if pulsation is not arrested, then it is probable that the vertebral is the artery affected, and ligature of the carotid is a useless proceeding.

The treatment of such aneurisms is very unsatisfactory; cases of cure are reported from continuous compression with shot-bag, but if this fail operative measures are of little avail; it is useless to ligature the artery low down, as the anastomosis above is so free; and if the aneurism is cut down upon, ligature at the seat of the aneurism is rarely satisfactorily completed. The writer once saw the carotid tied for vertebral aneurism due to a stab with a knife below the mastoid, and afterward the sac of the aneurism cut down upon; but the hæmorrhage could not be arrested by plugging, or otherwise, and the patient died. In this case pressure on the carotid against the sixth cervical

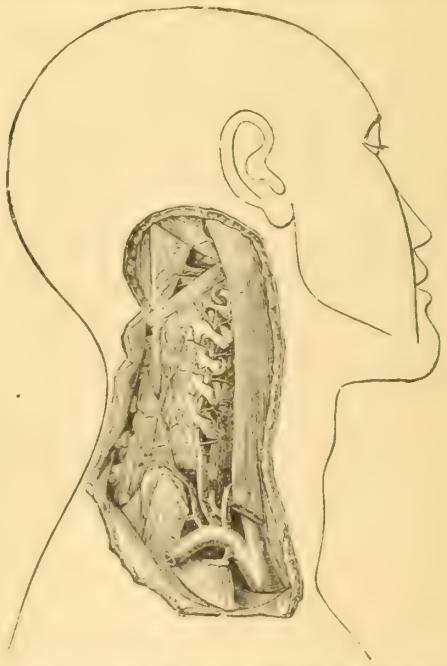

Fig. 2438.—Deep Dissection of the Neck, showing the Course and Origin of the Vertebral Artery (5). (Tiedemann.)

transverse process arrested pulsations in the aneurism, and it was supposed the affection was connected with the occipital artery.

Veins of the Neck.—The *anterior jugular* vein has already been mentioned as lying along the inner border of the sterno-mastoid. It varies somewhat as to its course, and is sometimes double. Occasionally, the veins of the two sides are connected by a large transverse branch, which is a source of trouble in the operation of

tracheotomy. The anterior jugular, if large and placed nearer the median line than usual, is liable to be wounded in tracheotomy. It might also be wounded in tenotomy of the sterno-mastoid for wry-neck. The two anterior jugulars may be replaced by a single trunk.*

In front of the trachea and thyroid gland is a large vein, the *inferior thyroid* (vena thyroidea ima), which, when large, complicates operations on the trachea.

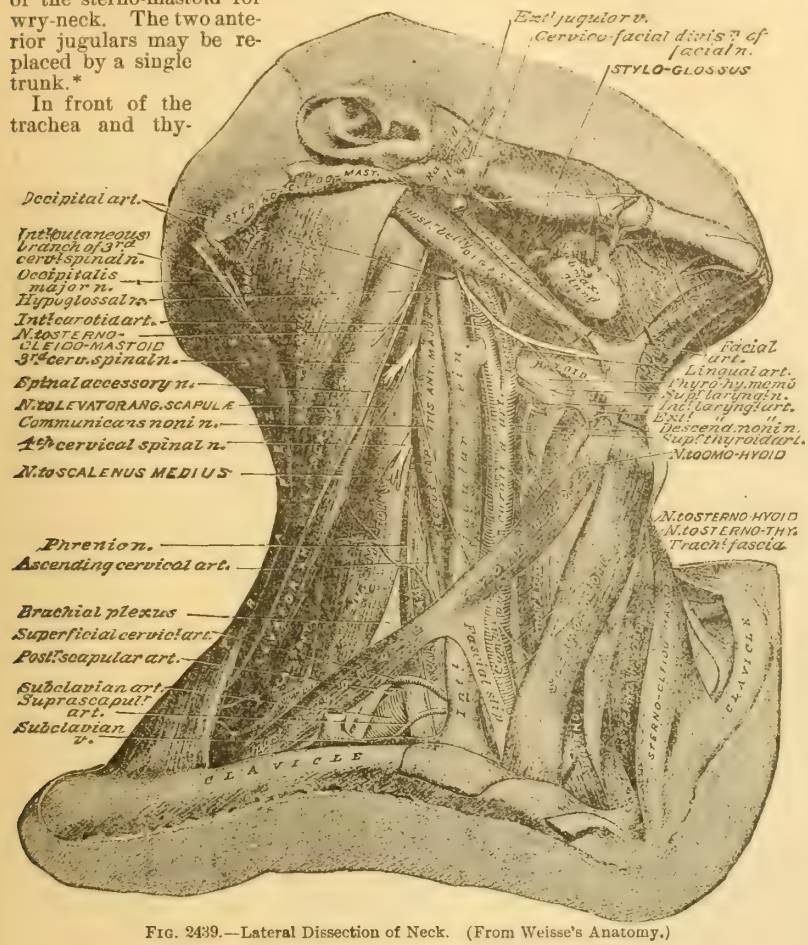

FIG. 2439.—Lateral Dissection of Neck. (From Weisse's Anatomy.)

The *external jugular* vein corresponds to a line drawn from the angle of the jaw to the middle of the clavicle; it runs beneath the skin and platysma and over the sterno-mastoid muscle, and ends by piercing the deep fascia above the clavicle to join the subclavian vein. In the operation of tying the subclavian in its third part, it must be held aside or ligatured.

The *internal jugular* vein lies to the outer side of the common carotid artery, and when distended partially overlaps it. In operations for the removal of tumors or enlarged glands of the neck, this vessel may be wounded; ligature in such accidents is the proper procedure, and is not attended by any evil after-effects. The writer has on three occasions ligatured the internal jugular with the most happy results.

The *subclavian vein* is a continuation of the axillary, and is in close relation with the clavicle; it lies in front of and below the subclavian artery, from which it is separated by the anterior scalenus muscle. On the left side the thoracic duct empties into it. The point of junction of the subclavian and internal jugular veins is opposite the sterno-clavicular articulation. The wall of the subclavian vein adheres closely to the fascial sheath by which it is invested; this sheath is connected anteriorly with the costo-coracoid membrane and the clavicle, and when the shoulder is carried forward the vessel becomes expanded (Quain). In operations at the root of the neck great care should be taken to avoid wounding the large veins, for air is very apt to be sucked in during inspiration. These veins are so firmly united to the bones and muscles, that when wounded they do not collapse, but, on the contrary, gape. It should be remembered that the risk of air entering is increased by movements of the upper limb, which still further open the wounded vein.

THYROID BODY.—This is a highly vascular organ consisting of two lateral lobes, one on each side of the larynx and trachea, connected by an isthmus which crosses the second and third rings of the trachea. The lobes are pear-shaped, and reach from the fifth and sixth rings of the trachea to the upper border of the thyroid cartilage; the lateral lobes are covered in front by the depressions of the hyoid bone, and posteriorly are in contact with the sheath of the great vessels of the neck. Each lateral lobe measures about 2 inches in length, 1½ in breadth, and ¾ to 1 inch in thickness. The weight of the thyroid body is from one to two ounces, and is greater in females than in males. The isthmus is occasionally absent, the lateral lobes being connected by fibrous tissue only, as is the case in some animals, viz., the horse, donkey, etc.

Owing to the fact that the thyroid body lies over the great vessels of the neck, when enlarged it derives from them a visible pulsation, and a distinct thrill may be felt. Such pulsating tumors have been mistaken for aneurism, but as the thyroid body is closely connected with the larynx and trachea, it rises and falls in deglutition, and so is easily diagnosed from aneurismal or other tumors, which are not disturbed by deglutition. When hypertrophied the tumor resulting from an enlarged thyroid is called a "*bronchocele*" or *goître*. When a goitre grows rapidly respiration is often interfered with, and operation has to be undertaken for its relief. It is not

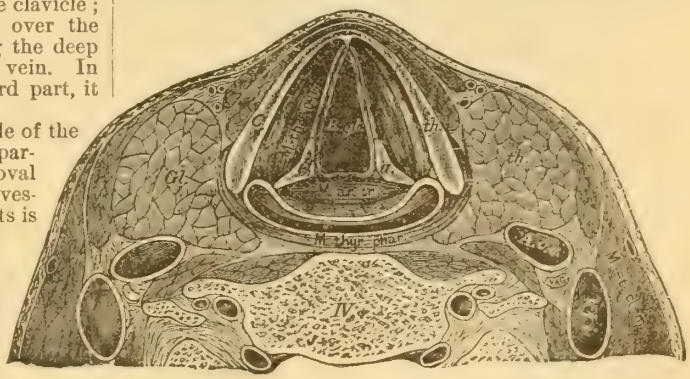

FIG. 2440.—Transverse Section of Neck, Opposite Fourth Cervical Vertebra, showing Thyroid Body.

* The anatomy of this region has been ably described by Dr. Pilcher in the Annals of Anatomy and Surgery, vol. iii., 1881.

necessary to remove the whole gland to relieve the obstructed respiration, for division and removal of the isthmus only often gives very good results. Mr. Sidney Jones (*Lancet*, vol. ii., 1883) reports cases where excision of the isthmus not only relieved the dyspnœa, but a month after the operation the lateral lobes had almost disappeared.

Since the advent of antiseptic surgery the extirpation of large bronchoceles by the knife has become most common, but the operation, owing to the very important structures in relation to it, is always a most formidable one. It is very important in this operation to first ligate the vessels supplying the gland, viz., the superior thyroid above, and the inferior thyroid below, and if present, the middle thyroid. In ligating the inferior thyroid artery, care must be taken not to injure the inferior laryngeal nerve, which winds among the branches of that artery. Simple primary thyroid cysts may be cured by puncture and injection of iodine. Owing to the conditions which follow complete removal of the thyroid, viz., myxœdema, and cachexia strumipriva, the operation is not now undertaken except in cases where life is threatened by the disease.

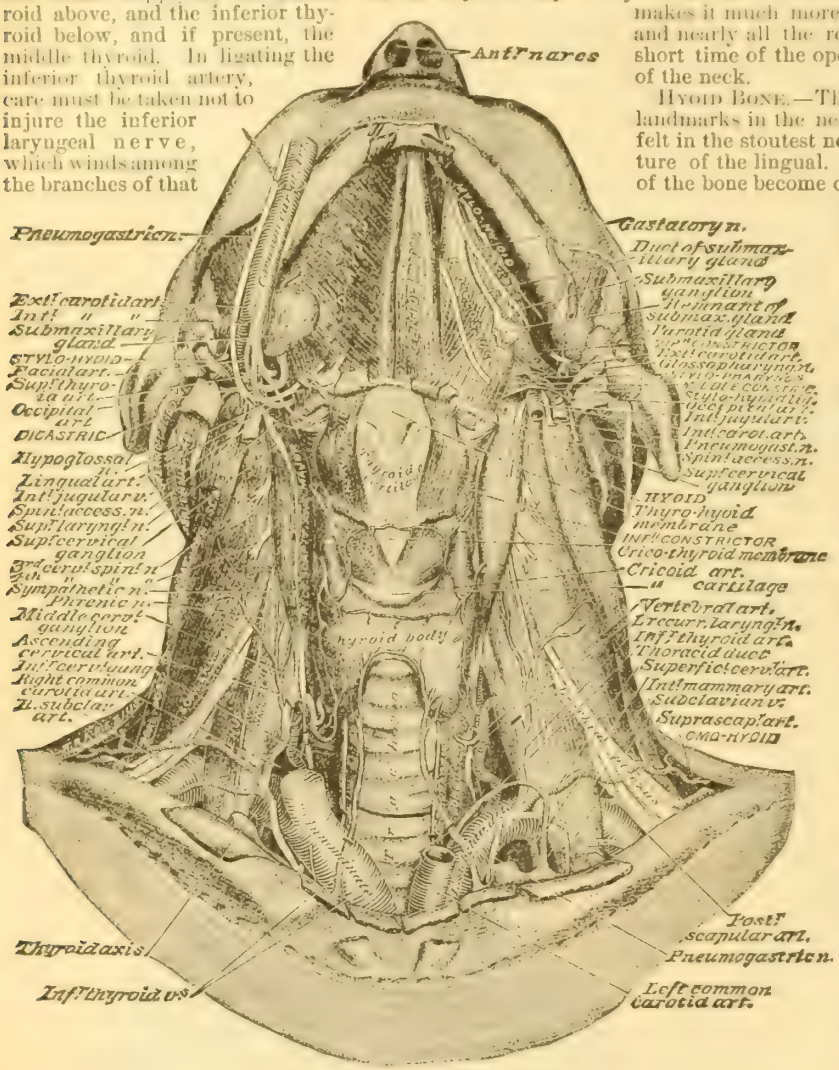

Fig. 2441.—(From Weisse's Anatomy.)

The Œsophagus commences opposite the cricoid cartilage, lying between the trachea and vertebral column. At the lower end of the neck it inclines a little to the left, and for this reason œsophagotomy is performed on the left side. Strictures most commonly occur at its upper part, and foreign bodies are most apt to be arrested behind the larynx. Foreign bodies, such as fish-bones, mutton- or beef-bones, have occasionally ulcerated through the œsophagus and perforated some of the large vessels with which it is in contact.

In performing *œsophagotomy* for the removal of an arrested foreign body, the incision is made between the sterno-mastoid and trachea, the middle point being opposite the cricoid cartilage. The inferior thyroid artery and recurrent laryngeal nerve must be carefully avoided. The carotid artery is in no danger of being wounded if proper care be taken.

In *œsophagostomy*, when a stricture exists high up, the incision into the œsophagus is made for the purpose of feeding the patient by a tube, and so avoiding gastrostomy. The fact that the operation is performed low down makes it much more dangerous than œsophagotomy, and nearly all the reported cases have died within a short time of the operation from diffuse inflammation of the neck.

Hyoid Bone.—This is one of the most important landmarks in the neck, and one which can always be felt in the stoutest neck. It is the best guide for ligature of the lingual. In old age the different portions of the bone become ossified into one piece, and in consequence it is more easily broken by direct violence due to blows or throttling. Cases are reported of fracture of the hyoid from yawning and sudden extension backward of the head. The symptoms of fracture are pain, difficulty in speaking, in movements of the tongue, and in swallowing.

Larynx and Trachea.—The *larynx* is connected above with the hyoid bone by means of the thyro-hyoid membrane, and is continuous below with the trachea. Posteriorly it helps to form the wall of the pharynx. It consists of several parts, which are closely connected together by ligamentous structures, muscles, and mucous membrane; these parts are the thyroid cartilage, epiglottis, cricoid, and arytenoid cartilages. On the upper margin of the thyroid cartilage is a bursa which prevents friction as the larynx ascends beneath the hyoid bone in deglutition. This bursa is sometimes enlarged, and has to be incised. The larynx is occasionally wounded in cases of attempted suicide by cutting the throat. Between the lower border of the thyroid and cricoid cartilages is the crico-thyroid membrane, where the operation of laryngotomy is performed. A small lymphatic gland is occasionally found here, which may become enlarged. (For description of interior of larynx see Larynx.)

Foreign Bodies.—Children not infrequently swallow articles which are sucked into the larynx during inspiration; these may be arrested by the cords at the rima, or may lodge in one of the ventricles. If they pass the rima they usually lodge in the right bronchus. These bodies can frequently be seen with a laryngoscope and extracted with forceps, but very often the operation of tracheotomy is necessary to remove them.

The Trachea extends from opposite the sixth cervical vertebra to its bifurcation opposite the third dorsal, where it is crossed by the arch of the aorta. It measures from four to five inches in length, and three-fourths to one inch in breadth. It is covered by the depressors of the hyoid bone, and has on each side at its upper end the thyroid body. It is crossed by the isthmus of the thyroid gland

opposite its second and third rings, and has also in front the inferior thyroid veins, and sometimes a transverse branch connecting the two anterior jugulars. When the middle thyroid artery is present it also lies upon the trachea in its course up to the isthmus of the thyroid. In children the thymus gland covers its lower portion. Laterally the trachea is in relation with the carotid artery and recurrent laryngeal nerve; posteriorly it is in contact with the œsophagus. The innominate artery crosses the lower end of the trachea: this occurs higher up in children than adults.

The operation of *tracheotomy* is performed above or below the isthmus. It is required for the extraction of foreign bodies and for any obstruction to respiration having its seat in the larynx, as from diphtheritic membrane, new-growths, etc. It is also performed as a preliminary to certain operations in the neck and mouth.

The distance between the cricoid cartilage and the upper border of the sternum, in ordinary individuals, is about one inch and a half (4 ctm.); when the head is thrown back three-fourths of an inch more is gained, so in performing tracheotomy the neck should be extended as much as possible by placing a hard round pillow under it, and the incision should be exactly in the middle line, so as to come between the two sterno-hyoid muscles and anterior jugular veins. In operating there is a choice

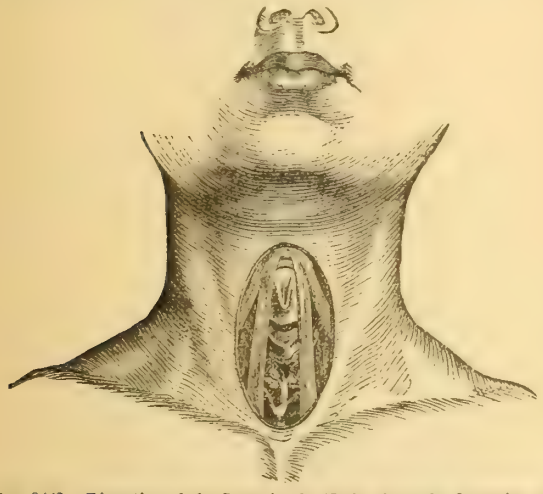

Fig. 2442.—Dissection of the Space in the Neck where the Operation of Tracheotomy is Performed. The trachea is exposed, having on each side of it the sterno-hyoid muscle, and lying on it below the inferior thyroid veins. (Roser.)

as to where the trachea is to be opened, either above or below the isthmus. Above, the parts are more superficial and blood-vessels fewer, but the space is limited and the cricoid cartilage has often to be cut; below, although the trachea is deeper and the veins more plentiful, still there is more room for incision, and we get farther away from the disease, which is an important point in diphtheria. With our present means of arresting hæmorrhage the low operation is to be preferred.

Laryngotomy is performed in cases where it is necessary to rapidly relieve suffocation, and in adults who have chronic affections of the larynx. It is performed by cutting the crico-thyroid membrane transversely.

(For more complete description of these operations see Tracheotomy.)

Lymphatic Glands of the Neck.—These are large and numerous. They frequently enlarge and inflame, and if not excised, break down and suppurate, leaving unsightly scars. In scrofulous subjects the glands of the neck are the ones most frequently enlarged. The enlargement is always the result of some irritation, either of the mucous membrane of the throat, nose, ear, etc., or of the skin of the scalp, face, or neck. The glands are more liable to enlarge in persons of a scrofulous diathesis, and in them the amount of involvement of the glands is out of all proportion to the irritating cause; this may be an eczema of the scalp or a simple sore throat. In non-scrofulous individuals the glands are frequently enlarged from some special irritating cause, as a diseased tooth, tonsillitis, malignant disease of the tongue, lip, etc., but in these individuals the affection of the glands is not so widespread, nor is the enlargement so great, and the glands do not tend to suppurate.

In syphilitics the *glandulæ concatenatæ* in the posterior triangle of the neck are frequently enlarged and indurated, but they do not tend to suppurate. In tonsillitis an enlarged gland is always felt beneath the angle of the lower jaw; this is erroneously supposed by many to be the enlarged tonsil which cannot be felt from the outside.

In eczema of the scalp the glands of the neck are frequently enlarged, especially if the eczema be of the pustular variety. In delicate children pediculi not only often cause an eczema of the nape of the neck, but the irritation frequently causes enlargement of the glands in the suboccipital and mastoid regions.

Occasionally a single gland becomes enlarged over the carotid artery, and this has been mistaken for aneurism on account of the strong pulsation communicated to the tumor by the artery; these tumors, however, cannot be emptied by lateral pressure, and when lifted away from the artery all pulsation, of course, ceases.

When one or several glands of the neck have become enlarged and show no tendency to diminish, it is much better to remove them with the knife. This can be easily done before the gland breaks down and suppurates, and so forms inflammatory adhesions to the surrounding parts. In cases of "scrofulous necks," where nearly all the glands are enlarged, their removal is advisable, for if left to themselves they break down and suppurate, and after months and perhaps years of discomfort, heal, leaving unsightly scars. An argument in favor of early excision is that foci of infection are removed, and the patient's chance of good health is much greater. Frequently thirty or forty glands have been removed at one operation, and the result is almost invariably good, the patient recovers rapidly, and the amount of scarring is very trifling. In dissecting out the glands in close relation to the large vessels, great care should be taken; after the gland has been exposed the removal should be completed with the fingers.

When the glands have suppurated and sinuses are left which will not heal, scraping the sinus and removal of the remains of the gland with a sharp spoon give very good results. Mr. Treves recommends puncture of softened caseous glands with a cautery; he also advises opening gland abscesses by the cautery highly heated.

The lymphatics of the neck are enlarged, with those of other parts of the body, in leukæmia and Hodgkin's disease, and care should be taken not to confound scrofulous glands with enlarged glands in these diseases. Removal of enlarged glands in Hodgkin's disease is, of course, perfectly useless.

The lymphatic glands of the neck are arranged in the following groups: *Submaxillary* (10 to 12 in number), situated beneath the base of the inferior maxilla; these also include the *supra-hyoid*, which are situated between the two anterior bellies of the digastric muscle in the middle line of the neck. *Superficial cervical* (4 to 6) situated along the external jugular vein beneath the platysma and deep fascia.

Deep Cervical (20 to 30).—These are subdivided into *superior* and *inferior*. The *superior* are situated about the bifurcation of the common carotid, and reach to the base of the skull, lying along the internal jugular vein. The *inferior* are grouped around the lower part of the internal jugular vein, and extend outward into the supraclavicular fossa, becoming continuous below with the axillary and mediastinal glands.

The following table, from Mr. F. Treves' book on "Scrofula and its Gland Diseases," showing the relation certain glands bear to the periphery, will be found useful:

Scalp: Posterior part = suboccipital and mastoid glands; frontal and parietal portions = parotid glands;

vessels from the scalp also enter the superficial cervical set of glands.

Skin of Face and Neck = Submaxillary, parotid, and superficial cervical glands.

External Ear = Superficial cervical glands.

Lower Lip = Submaxillary and supra-hyoid glands.

Buccal Cavity = Submaxillary and deep superior cervical glands.

Gums of Lower Jaw = Submaxillary glands.

Tongue: Anterior portion = supra-hyoid and submaxillary glands; posterior portion = deep cervical glands (superior).

Tonsils and Palate = Deep cervical glands (superior).

Pharynx: Upper part = parotid and retro-pharyngeal glands; lower part = deep cervical glands (superior).

Larynx, Orbit, and Roof of Mouth = deep cervical glands (superior set).

Nasal Fossa = Retro-pharyngeal glands and deep cervical (superior). Some lymphatics from the posterior part of the fossa enter the parotid gland.

Parotid Gland.—This gland lies on the face in front of the ear, and extends deeply into the space behind the lower jaw; its inferior portion is situated partly in the neck behind the angle of the jaw, lying on the digastric muscles in the submaxillary region. It is connected with very important structures, being pierced by the external carotid artery and facial nerve. This gland not infrequently becomes inflamed and suppurates after fevers (as typhoid) and injuries to the abdomen. Cases are reported where it has become inflamed after ovariotomy, and the writer has twice seen abscess of the parotid follow severe blows on the abdomen. These abscesses are very painful, owing to the tension caused by the investing fibrous capsule. In opening abscesses here the incision should be transverse, to avoid cutting the facial nerve, and should be in front of the line of the carotid artery. Abscesses of the parotid gland frequently burst

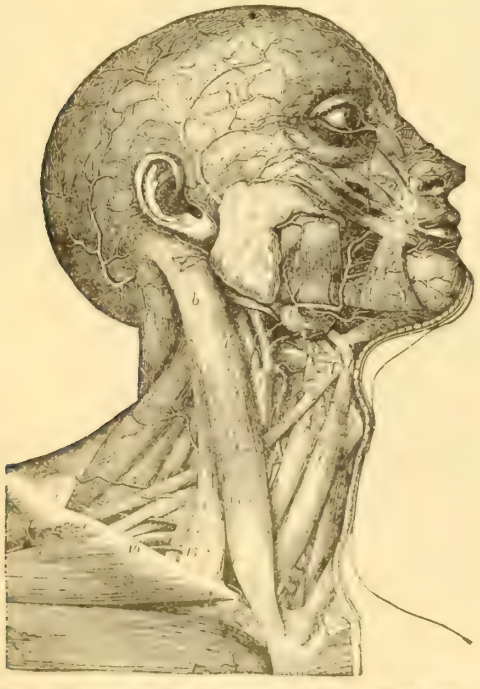

Fig. 2443.—Dissection of Neck, showing the Submaxillary and Parotid Glands, and their Relation to the Facial and Carotid Arteries. (Tiedemann.)

into the external auditory meatus. There are a number of lymphatic glands in relation with the parotid, which receive vessels from the scalp, pharynx, etc. Tumors are not infrequently found in this region, the extirpation of which gives rise to very severe hæmorrhage. The facial nerve is frequently unavoidably injured in the removal of these tumors, and the external carotid artery sometimes requires ligature.

Submaxillary Gland.—The submaxillary gland is situated in the submaxillary region, between the anterior and posterior bellies of the digastric muscle. It lies partly on the mylo-hyoid and partly beneath it. The facial artery grooves the back part and upper border of the gland. The gland is sometimes involved in malignant diseases affecting the mouth and tongue. It is separated from the parotid gland by a fold of deep cervical fascia, the stylo-maxillary ligament.

Nape of Neck.—The superficial anatomy of this region has already been described. The most superficial

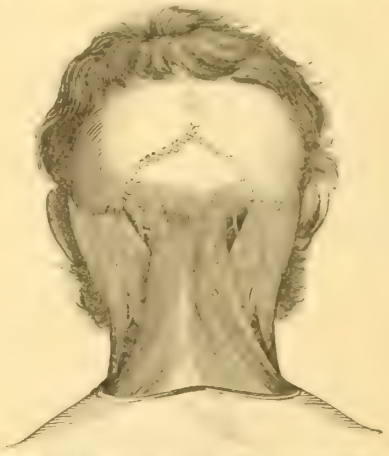

Fig. 2444. The Skin and Fascia have been Removed, and the Superficial Muscles Exposed. 1, Sterno-mastoid; 2, splenius capitis; 3, trapezius; 4, small occipital nerve; 5, great occipital nerve; 6, vertebral artery. (After Roser.)

muscle is the trapezius, which is covered by a layer of thick and tough fascia and is pierced by the great occipital nerve. To the outer side of the trapezius, and separated from it as it descends, is the sterno-mastoid muscle; crossing obliquely the interval between them are the splenius capitis and colli muscles. On removing the trapezius, which in this region is usually very thin, the complexus muscle comes into view, also pierced by the great occipital nerve; deeper down still are seen the muscles bounding the suboccipital triangle (rectus capitis anticus major, superior and inferior oblique), where is seen the suboccipital nerve and vertebral artery (see Fig. 2444). In the central line is the ligamentum nuchæ. It extends from the seventh cervical spine to the external occipital protuberance. In some animals this ligament is a very powerful elastic band which suspends the head; to it are attached muscles and fascia. The occipital artery becomes superficial midway between the mastoid process and external occipital protuberance. It runs along the outer border of the superior oblique, and is accompanied by the great occipital nerve. The lesser occipital nerve winds round the posterior border of the sterno-mastoid, and supplies the lateral region of the occiput; the suboccipital, being a purely motor nerve, rarely reaches the skin.

Spinal Cord and Vertebral Column.—The accompanying figure (2445) shows well the situation of the spinal cord in the neck vertebræ. It is not so well protected against injury as in other parts, for in the space between the several arches, any sharp instrument piercing the muscular tissue could easily wound the cord. The vertebral artery, as has already been mentioned, is also liable to injury on its way from one vertebra to another. From the great mobility of this part of the spine dislocation occasionally occurs and death is caused by pressure on the cord. In caries of the upper cervical vertebræ, sudden death has taken place from the destruction of the ligaments between the atlas and axis. When this occurs —the head with the atlas inclining forward and leaving

the axis in its proper position—the medulla oblongata is crushed against the odontoid process, and so instant death is the result (Hilton).

Caries of the spine in the cervical region is not uncommon. In its early stages the symptoms are somewhat obscure, the chief symptoms are pain in the course of the great occipital nerve, due to its implication in inflammatory exudation. The peculiar stiff way in which the patient carries his head, and the presence of a slight prominence which is excessively tender, enables the surgeon to recognize the disease. These cases occasionally result in a post-pharyngeal abscess, which has to be opened. This may easily and safely be done by an incision along the posterior border of the sterno-mastoid. Some advise tapping it with a trocar through the mouth.

Branchial Fistulæ and Cysts.—In the mammalian embryo, at the fourth week, there are on each side of the head, behind the oral cavity, four fissures which communicate with the anterior part of the alimentary canal. These are the homologues of the clefts found in branchiate vertebrates. The third and fourth fissures in the human embryo disappear about the sixth week, and only the first remains at the end of the ninth week. This persists as the Eustachian tube, tympanic cavity, and external auditory meatus. The structures developed in the folds between the clefts (branchial arches) are as follows:

First Arch (*Mandibular*): Meckel's cartilage, the anterior portion of which is developed into the lower jaw, and the mandibular arch is completed by the malleus bone of the ear.

Second Arch (*Hyoid*): Incus, stapes (Parker), styloid process, stylo-hyoid ligament, and lesser cornu of the hyoid bone.

Third Arch: Great cornu and body of the hyoid bone.

Fourth Arch: No permanent remains.

Sometimes the clefts between these arches remain more or less open, and this fact explains the occurrence of con-

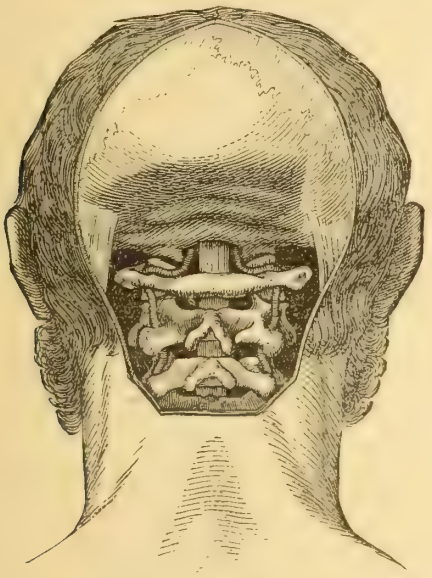

Fig. 2445.—The Superficial Tissues have been removed to show the Vertebral Artery passing through the Transverse Processes of the Vertebræ, and also the Relation of the Cord to the Spinal Canal. (Roser.)

genital fistulæ of the neck, also cysts and diverticula from the œsophagus and pharynx.

Paget says (*Proced. Royal Med. Soc.*, 1877), "Cervical branchial fistulas occur as two or three minute orifices on one or both sides of the lower part of the neck, and they lead upward to the œsophagus and pharynx; the lowermost being near the sternal end of the clavicle in front of the sterno-mastoid muscle, the next opposite the thyroid cartilage, and the highest between the thyroid cartilage and hyoid bone." When two in number, they are often symmetrical; they vary in length from one half to one and a half inches, and barely admit a probe. They have a smooth lining membrane, which secretes a

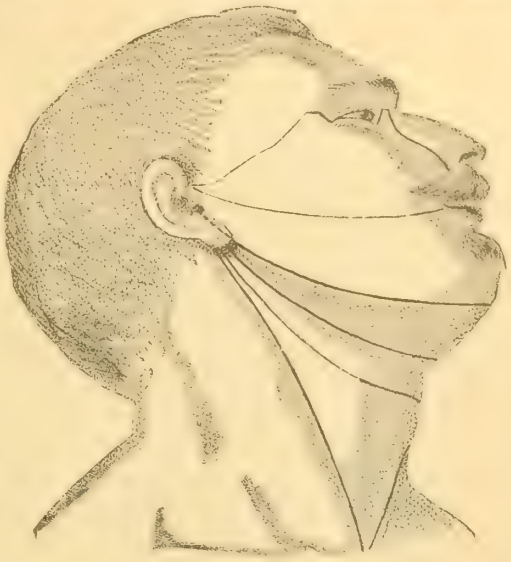

Fig. 2446.—(From Cusset.)

clear mucous fluid. These fistulæ can be cured by cauterizing them with the galvano-cautery. It is probable that many cysts and so-called hydroceles of the neck are due to imperfectly closed embryonal fissures.

Sanguineous cysts of the neck are probably originally branchial cysts, which have communicated with the internal jugular vein. Cases are on record in which, before removal of the cyst, the vein had to be ligatured (Glück: *Deutsche Med. Woch.*, No. 5, 1886).

Tumors of the Neck.—The neck is a favorite site for tumors, fibrous, sarcomatous, and others. Sarcomatous tumors in the early stages can be removed, but they nearly always recur. Tumors of the neck, which are apparently so freely movable that their extirpation would seem to be an easy matter, are found, when cut down upon, to be intimately connected with the deep vessels and nerves. In these cases the tumor is freely movable laterally, the vessels going with them, but there is no freedom of movement in the vertical direction. It is remarkable with what impunity large tumors may be removed from the neck, especially if benign. It is not uncommon in these cases to ligature both the internal jugular vein and carotid artery, and to cut through the sterno-mastoid muscle, and yet have the patient make a rapid recovery from the operation; the tumor as mentioned above, if sarcomatous, almost invariably returns, for it is impossible in the neck in such cases to remove sufficient of the surrounding healthy structures.

Aneurismal tumors at the root of the neck are comparatively common, and although in many cases these tumors may have the appearance of being connected with the subclavian or innominate arteries, yet they almost invariably proceed from the aortic arch, and push their way upward under the clavicle into the neck. Fusiform aneurisms of the aorta frequently simulate aneurism of one of the great branches.

Tumors in connection with the thyroid gland have been alluded to in the description of that body.

Francis J. Shepherd.

NECROSIS. The word necrosis, strictly speaking, means the condition of death. Technically, it signifies the sum of the actions which terminate in the death of a portion of the skeleton, osseous or cartilaginous. The term, therefore, stands not for a particular disease so much as for a result, to which many forms of disease

of bone commonly tend. This resulting condition, however, is so prominent a one in the case, it gives so many characteristic features to its history, and dominates so completely its later stages, that it has been found, both by clinicians and pathologists, convenient to use the name of this symptom as best suited to characterize the affection, of which at most it is a mere accident. It is an accident, however, which under certain conditions is so prone to occur, that the question naturally arises, Why is it that bone is so liable to die, when affected by certain diseased conditions which, when present in the softer tissues, produce no such fatal effect?

The answer to this question may be found in the anatomical formation of the bone. In the first place, it must be remembered that the periosteum, by its deeper or osseous layer, affords, through numberless small vessels, the entire blood-supply of the superficial layers of the bone. This periosteum is liable to be separated from the bone in many different ways. For example, it may be stripped off by direct violence; it may be raised from the bone by the effusion of blood between it and the bone; or, what is probably more common, it may be separated from the bone it covers by the effusion of the products of inflammation, especially of pus. In either of these ways the circulation is cut off in the denuded layers, and they perish from simple inanition.

But besides this merely mechanical cause, there is, in the structure of the compact tissue of bone, an explanation of the readiness with which it falls into necrosis. The Haversian canals are filled completely by the vessels which run in them, and by the cell structures which are packed tightly round these vessels, so that when the inflammatory nisus calls for larger blood-currents and more blood-cells, there is no room for the enlargement of vessels thus imperatively called for, and the consequence is that the vessels, not having this power of accommodating themselves to this new and sudden demand, become early choked, and the circulation fails to be maintained, and in consequence the portions of bone most deeply involved die.

These considerations very naturally suggest the principal causes of necrosis. Of these causes, inflammation undoubtedly holds the highest place. Any condition of inflammation which separates the periosteum from the bone, any degree of inflammation which chokes the capillaries of any part of the compact tissue of any bone, is liable to be followed by the death of the part affected. The study of causes of necrosis is, therefore, largely the study of the various forms of inflammation of the bones. Of these forms of osteitic inflammation, much interest has recently centred in that commonly spoken of as osteomyelitis. This disease, whose principal inflammatory features are shown in the medulla, is a not infrequent cause of necrosis, besides being a fatal feature in a large number of open injuries of the bones. It has long been suspected to be of an infectious and specific nature, but recently the labors of Rosenbach, Krause, Becker, and Garrè, have drawn special attention of pathologists to the bacterial element upon which it has been supposed to depend. This element has been recognized by each of these observers, and it was at one time thought that the specific form had been found. The latest reports, however, seem to leave it doubtful whether any specific bacterial form has been discovered which can be proved to be the micrococcus of osteomyelitis, the staphylococcus pyogenes being common to this disease and a number of others in which suppuration is a prominent feature.

Besides these inflammatory causes there are certain others in which embolus and thrombosis, chiefly of small vessels, or of capillaries, play an important part by local arrest of circulation, as in certain cases of septic disease; and still others in which the embarrassment of the circulation is due to certain mechanical conditions following injury, as in stripping off of the periosteum and in effusions of blood between the periosteum and the bone. Phosphorus, directly, and syphilis, indirectly, stand for the causes of a considerable number of necroses, neither of them, however, showing as frequent victims now as in former times, when we were less able to guard against their injurious effects. Besides all these causes of necrosis we are forced to recognize that, in certain other cases, repeated attacks of bone disease occur, chiefly during the period of adolescence, in which the causes escape our scrutiny so completely that we speak of them as spontaneous.

The seat of necrosis is generally the compact tissue, though the cancellous is sometimes affected by it. The bones most liable to this affection are first, the tibia, the shaft of which is more often affected than any other point in the skeleton. After the tibia comes the femur, then the humerus, the cranial bones, lower jaw, last phalanx of finger, clavicle, ulna, radius, fibula, scapula, upper jaw, pelvic bones, sternum, and ribs, in the order in which they are named. From looking over this list it is not easy to discern the reasons why one bone should be more liable to necrosis than another, but in the case of the tibia it has been supposed that its superficial situation, and its exposure to cold and wet, and to injuries of all kinds, may explain the undoubted fact that it is more frequently the seat of necrosis than any three other bones of the skeleton taken together. The cases in which the cancellous suffers with the neighboring compact bone are not very rare, but of the form in which the cancellous tissue alone becomes the seat of necrosis, cases are very unusual. Perhaps the most frequent seat of pure cancellous necrosis is found in the os calcis, of which a number of examples are reported, and more rarely in the sternum, pelvic bones, and the ribs. These latter, however, are usually secondary accidents in the course of syphilitic or tubercular caries.

The clinical history of necrosis is commonly that of an acute affection, in which the death of bone occurs early in the case; while the later symptoms, which are due to the presence of the dead bone in the living tissues surrounding it, often make up a tedious history of chronic suffering occupying months, or, if surgical relief be not afforded, even years before the morbid actions terminate in health. The severity of each case will probably show a distinct relation to the extent of the mortified tissue. This extent, of course, varies much in different cases. It may be superficial, or it may involve the whole thickness of the bone. It may be limited to a small segment, or it may involve the whole shaft, and in a few instances it has been found that an entire bone has perished. In by far the larger number of cases it is a limited portion of the shaft of one of the long bones that furnishes the sequestrum. These varieties may be classed as: 1, The superficial; 2, the internal, or central; 3, the complete, where the whole thickness, but not the whole length, of the shaft has suffered; 4, the total, where the entire bone has perished.

In studying this disease it will be convenient to take an example occurring in a long bone, in a healthy, young individual; and in such a case it will be proper to take up in order: 1, The pathological conditions characterizing each stage; 2, the symptoms which belong to these pathological changes; and 3, the treatment appropriate to each.

The first pathological condition we may consider to be the death of the bone. It is true this is preceded, in different cases, by different morbid states upon which the death depends, which morbid states form an important part of the chain of processes to the whole of which we give the name of necrosis. Still, as the affection cannot be considered a necrosis till the death has actually occurred, this fact of death is the proper point at which to begin our studies. When death has occurred a change takes place in the color of the dead part, by which it can usually be easily distinguished from the living. It has a yellowish, tallowy look, it does not bleed when cut, and is more easily separated from its periosteal covering. From this point it undergoes no change, except such as may be impressed upon it by outside influences. It remains in all respects a foreign body within the living tissues, from which it has to be separated and expelled by a succession of surprising and most interesting processes. Whether it is capable of being absorbed by the living textures in contact with it has always been a mooted point; but it

seems to be agreed that, under certain conditions, and to a very limited extent, such absorption is possible.

In a healthy individual the process of separation begins very promptly, and takes place by, first the decalcification, and then the removal by absorption of the living particles in contact with the dead ones. This absorption is usually quite free, so that when it is completed the sequestrum is left in a cavity considerably too large for it. The space thus left by absorption is soon filled up by granulations springing from the surrounding soft tissues and from the living bone, which line the cavity completely, and thus we find, when the process is completed, the sequestrum lying in a cavity which is lined by a firm, ruddy granulation cushion, which so closely embraces the sequestrum as to prevent any painful movement of it in its bed. Thus protected, the presence of the sequestrum is tolerated by the soft parts without suffering, sometimes during many years.

The dead bone, separated from its connection with the living, now lies enclosed in its granulation-lined cavity, and now is properly termed the sequestrum. While it remains unchanged very interesting and important actions are being instituted in the surrounding parts, the object of which is to protect the limb from the consequences of the breach of continuity which has, by the separation, been effected in the bone. These actions have for their final result the formation of an osseous bond of union between the separated parts, which appears in the form of a ferule of new bone formation, which is attached, above and below the breach, to the sound bone; which ferule, when it is finally ossified, is sufficiently strong to restore the divided bone to its original strength, and in many cases to make it thicker and stronger than it was before the disease commenced. The mode in which this connecting ferule is formed is substantially as follows:

When the process of separation is complete we have found the sequestrum lying loose in a cavity lined by granulations springing partly from the living bone and partly from the inner face of the periosteum, where it has been detached from the sequestrum. It is from the ossification of these granulations that the new bone is formed. Ollier has shown that the bone supplies but little of the new material, but that by far the greater part is contributed by the periosteum, of which membrane only the deepest layer, that in contact with the sequestrum, has any osteo-genetic power. The bone, the medulla, and even the surrounding soft parts are capable of some effort in the direction of new bone-formation, but the result is so inconsiderable and so uncertain that, practically, the periosteum may be considered as the only source to be relied on to furnish the necessary consolidation; and from this fact may be deduced the surgical rule to preserve every portion of periosteum that can be saved, in every case where we desire reparation by bone.

The process of separation is not accomplished without the formation of pus. We find, in fact, that, as the separation takes place, the space between the dead bone and its living surroundings has become an abscess cavity, in which pus accumulates, sometimes in large quantity, until finally it makes its way through the periosteum spontaneously, or is released by the surgeon's knife. We have, therefore, while the process of bone deposit is going on, a constant formation of matter from the inner surface of the cavity in which the sequestrum lies, and this suppuration continues in greater or less abundance till the foreign body, for such the sequestrum has now become, is removed.

The deposition of new bone takes place from the surface and in the substance of the osteo-genetic or deepest layer of the periosteum, in connection with some deposit from the sound bone above and below, and the bridge or ferule of bone thus formed is perforated at one or more points by the openings which were originally made in the periosteum for the escape of the imprisoned pus. These openings are called the cloacæ, and much of the comfort of the patient, during the time he is carrying his sequestrum, depends upon the freedom and directness of these openings. The new bone thus deposited outside of the dead portion of the shaft of course increases the thickness of the bone at this point, so that it not infrequently becomes more than twice the thickness of the original bone. These two processes, of sequestration and involucration, go on together, so that while the separation is proceeding the compensatory ossification is being accomplished, and as a result we have the bone so strengthened by the time of separation, that in many cases there has been no time when it has not been capable of performing its functions of support and locomotion.

With the completion of these processes of sequestration and involucration the pathological actions seem ordinarily to terminate. Henceforward no change occurs either in sequestrum or involucrum. The dead bone remains resting upon the granulations lining the inner surface of the involucrum, which granulations continue to shed a moderate amount of pus, which escapes through cloacæ, and thence through fistulous canals to the surface. This state of affairs may last indefinitely, if one of two things does not happen: either, first, that the sequestrum makes its way to the surface and is discharged; or, second, that a surgical operation be performed, whereby the involucrum is opened and the sequestrum removed from its cavity. If either of these events happen, then the granulations gradually fill up the cavity, the fistulæ close, and the wounds finally heal. It is important to remark that, in the healing of such a wound, nature does not supply additional bony deposits to fill up entirely the vacancy left by the removal of the dead bone. In the very young we may hope for greater bone restoration than in the adult or the old; but I believe that in no case is the cavity entirely obliterated by bone, the space being occupied only by a firm fibrous tissue, which adds but little to the strength of the bone. Even this fibrous tissue is not usually found in sufficient abundance to entirely fill the cavity, and accordingly, in every case of necrosis of the shaft of a long bone after operation, there is left a depressed cicatrix, the depression representing the loss of substance which has not been replaced either by bony or fibrous tissue. It should still further be noticed, in this connection, that the chiselling away of the anterior surface of the involucrum means the destruction of the periosteum at that point, and that therefore no bony deposits can be expected to replace the portion of involucrum that has thus been removed. These considerations, it seems to me, should suggest great care in removing involucral bone in any and every case of operation for necrosis, and also that, whenever it is possible, the removal should be in the longitudinal rather than in the transverse direction.

We are now prepared to study and to appreciate the symptoms which present themselves in the progress of the typical case we have taken for our example. Of course, the earliest symptoms are those of the inflammation which is about to result in the death of some portion of the inflamed bone. Usually the attack is quite sudden and the symptoms acute. The fever runs rapidly high, with or without an initial chill, and the local symptoms soon become very marked, particularly the swelling. If the attack light upon the upper or lower part of the shaft, near to the joint, the swelling is apt to be mistaken for that of rheumatism; where it is confined to the middle portion of the bone, the existence of acute osteitis is more likely to be early ascertained. Soon the swelling concentrates itself and becomes greater and greater, the fever and suffering more and more intense, until after the lapse of several days fluctuation reveals itself, and the surgeon's knife gives issue to the pent-up pus. From this the symptoms rapidly improve, the fever ceases, the pain is gone, and the patient flatters himself with the hope of a prompt and perfect cure. The opening, however, does not close, some pus continues to be discharged, some soreness continues, and the swelling does not entirely subside. After the lapse of a few weeks, during which the patient has regained a certain amount of use of the limb, it begins to be observed that the swelling has changed its character. The thickening and infiltration of the soft parts have gradually subsided, and the skin has regained its normal appearance, but deep in the centre of the limb the bone presents an enlargement, which

corresponds to the part of the bone involved, and is evidently due to the formation of the involucrum as above described. This is the condition in which those suffering from necrosis most frequently come under the notice of the hospital surgeon, or the consulting surgeon in private practice. The diagnostic features of the case are now well marked, and rarely leave much room for doubt. The limb is swollen and the swelling is hard, central, with sound and pliable soft parts covering it. At one or more points orifices exist, surrounded by pouting granulations, which orifices are the external openings of sinuses leading down, through the involucrum, to the cavity in which the sequestrum is imprisoned. A probe passed into one of these sinuses detects the bare surface of the dead bone, and thus confirms the diagnosis. The discharge of pus is small and of a normal character. This condition may remain without change for an indefinite period, the patient meanwhile regaining excellent general health, and remaining free from much local suffering, and even from any disability of the affected limb. This comfortable state of things is not by any means always realized. The parts are liable to excoriation, to attacks of pain and soreness, to attacks sometimes of severe inflammation, resulting in increased discharge, and for a time a high, though short-lived, fever. If the disease be near a joint, it is liable to be gradually stiffened by the subacute inflammatory actions going on in its immediate neighborhood, and as a consequence, if the sequestrum be allowed to remain during a long period of time, we have finally produced an anchylosis, so complete as practically to abrogate all its functions as far as locomotion is concerned. It may also happen, during this period of retention of the sequestrum, that the discharge may become excessive and exhausting, breaking down the general health and impairing the reparative energies so greatly that even a fatal issue might be apprehended if the cause of the trouble cannot be reached and removed.

The history of a typical case of acute necrosis, which has been given above, must be supplemented by a brief study of certain classes of cases which deviate in some important particulars from the usual, and what may be called the classical, course of the disease. Of these we have:

1. The Superficial Necrosis or Exfoliation.—There are cases in which a comparatively thin surface-layer of bone becomes necrosed and separates as a thin plate or leaf, from which it has derived its name. As a class they are limited in extent and slight in severity, and they are characterized by the pathological fact that very little or no reparative or compensatory process is set up in the way of involucral formation. Accordingly, when the process of separation is completed the sequestrum lies free on the surface of the bone, only covered by soft parts. These thin, leaf-like sequestra, therefore, easily extricate themselves by a process of ulceration through the superjacent integuments, or a slight incision will enable the surgeon to remove them. There are cases, however, of superficial necrosis which, by their extent, prove formidable. It happens sometimes that the whole or the greater part of the anterior surface of the tibia, for example, becomes necrosed and separates in the form of a long flake or plate, necessitating a correspondingly long incision for its removal. Still more serious and embarrassing are those cases in which, generally from very extensive suppurative inflammation, the whole superficial compact layer of bone is destroyed, leaving the central parts unaffected. In such a case the surgeon finds, on exposing the bone, that he has to deal with a tube of exfoliating osseous tissue surrounding the whole bone, the deeper parts of which are, of course, inaccessible to his first-planned incisions, and which require a severe and extensive operation before they can be removed.

2. Necrosis Attacking Cranial Bones.—Necrosis of these bones arising from ordinary traumatic or inflammatory causes differs in no respect from the disease as seen in other parts of the skeleton. There are a certain number of cases depending upon constitutional cause, however, which require a word of special notice. Of these the syphilitic are the most frequent and the most important. They belong to the tertiary group of manifestations, and are chiefly found on the vault of the cranium. The diseased action begins as a small, tender, elevated lump, which pretty rapidly grows larger, and soon inflames and ulcerates, and exposes the surface of the underlying bone. This is soon observed to be bare, and the bare spots, after a brief interval, become necrosed, the death of the bone extending its area gradually, until large surfaces of the cranial bones become involved in the necrotic process. This extension seems to occur by a localized inflammation with a spongy thickening of the diseased bone, and increased vascularity. This inflammatory swelling of the bone soon terminates in death of the part earliest affected, while the rest is going through the same stages, in its turn, to terminate in a similar manner. In this manner extensive districts of the skull are involved, so that, in one of the cases, my notes say that fully one-half of the cranial vault was necrotic, and in another (see Fig. 2447) the whole surface was more or less involved in the destruction. The death at most points does not go deeper than the external lamina, but in each of the instances I have had a chance to study, there have been found spots

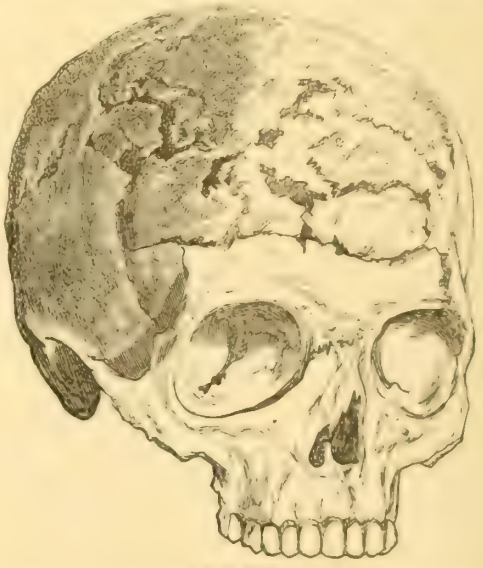

Fig. 2447.

where the whole thickness of the bone has been involved, the vitreous table being separated from the dura mater by a layer of thick pus, some of which would occasionally escape externally through openings made by an ulceration which seemed in each case to precede the actual death of the bone. Fig. 2448 shows one of these larger sequestra, in which at several points it can be seen that both tables are involved. The surrounding integuments are at first undermined by the bone-disease, and soon begin to ulcerate, leaving the dead and dying bone more or less completely exposed. When any arrest of the disease occurs, healthy, reparative-looking granulations spring up and an effort seems to be made toward cicatrization. This proves to be an illusive hope, however, for, after a short delay, the disease in the bone resumes its fatal course, and the same story is repeated week after week, month after month, until the patient dies, worn out by his exhausting malady, or, as in my first case, until some acute meningeal inflammation puts a merciful period to sufferings which art and science can do but little to mitigate. A very striking feature of this form of necrosis is found in the fact that the process of separation is so slowly, and, as it were, unwillingly, performed. In one case which I saw with the late Dr. John Watson, there seemed to be good evidence that the condition of necrosis of a certain plate of bone had existed for three years, and yet, on stripping back the soft parts, not only was there no

separation of the dead from the living bone, but no trace of a line of demarkation could be discerned, and it was only by finding that one part of the bone bled when cut and the other did not, that we could decide that one part was living and the other was dead. Another noticeable feature is the very slow progress and the inveterate persistence of the disease. Leaving out of consideration now the cases which died of meningitis, the rest occupied many months and years in their history. One of the cases, which was several times operated on, was observed during three years and a half, and another over six years. In both the general health was fairly good; they had no other manifestations of syphilis, and yet in each, after all these years and all the operations which had been performed, there were still evidences of diseased bone, showing that the disease was still in steady progress. So far as clinical experience has as yet been recorded, no

Fig. 2448.

specific treatment has been found for this distressing disease, nor any remedies which seem to exercise a direct influence on its progress.

3. Necrosis Occurring in the Jaw-bones.—These bones present frequent examples of necrosis. Most of these cases, arising from the ordinary causes of the disease, present no special features. Two classes of cases occurring in the jaws require special mention: 1st, those which arise in the course of certain eruptive fevers; and 2d, those which are seen among the workers in phosphorus. The first of these is most commonly developed during the course of scarlatina, or some of the severer forms of the other eruptive diseases. The history of the affection is about as follows: During the early convalescence from the eruptive fever, the gums of the child are noticed to be swollen and spongy, the teeth loosen and fall out, and the periosteum of the alveolar process begins to separate from the bone. A profuse discharge of fetid pus accompanies this stage of the disease, and as the periosteum shrinks away from the bone the latter is found to be in a condition of necrosis. The death of bone seldom reaches beyond the alveolar portions of the jaws, and seems to be self-limiting; for, after a few weeks, the dead portions begin to separate and come away in one or more pieces, leaving a cavity which soon fills up with healthy granulations, and the wound heals promptly, a deep excavation remaining, the worst feature of which is that all the teeth, both temporary and permanent, of the diseased portion are destroyed. The disease affects by preference children from three to eight years of age, and does not appear to have any distinct relation to the severity of the original attack. Mr. S. I. A. Salter was the first to bring this affection to the notice of the profession, in a paper which he published in "Guy's Hospital Reports," and remarks that it requires no treatment other than local cleanliness and a general tonic and supporting regimen.

The second kind of jaw necrosis, that depending upon the action of phosphorus, presents many points of pathological interest. These cases occur almost exclusively among the operatives in match factories, who are living in an atmosphere containing the fumes of phosphorus and phosphorous acid. The workmen most liable to be affected are those employed in the dipping-room, and in the packing-rooms. In the first there is a constant prevalence of the fumes of the volatilized phosphorus, and the air in the second is still further vitiated by phosphorous acid from the frequent burning of the matches while being counted and packed. It is believed that these phosphorous emanations, which are quite soluble in water, are dissolved in the saliva, and thus come in contact with the teeth and gums, upon which latter the poison seems to exert its primary influence. Why these particular parts are selected by the poison in preference to the rest of the buccal and to the Schneiderian membrane, which are equally, if not more, exposed to its action, is a pathological fact which we are not able to explain. That the poisonous action is a local, not a general, one seems further proved by the fact that constitutional cachexia does not often appear as a condition preceding the local outbreak; and still more strongly from the fact that if the teeth be sound, and the gums unbroken, the disease is rarely developed. On the other hand, it ought to be stated that there are sometimes evidences of slow systemic poisoning by phosphorus, terminating in necrosis; and also that it is rarely those who have been for only a short period subjected to the poison who develop necrosis, but rather those who have been some years in the occupation. Again, it has been recorded that the prolonged internal use of phosphorus may lead to typical necrosis of the jaw, as in a case recently reported by Mr. Hutchinson. It may, therefore, in the light of our present knowledge, be assumed that the action of the poison, at least in most cases, is purely a local one, though the system is probably predisposed to the local outbreak by a constitutional infection from the poison slowly introduced into the blood, either by inhalation of the vapor or by the ingestion of the drug as a medicine. It acts by inflaming first the gums and the linings of the tooth-sockets, from these spreading to the alveolar processes of the bone, and finally, by extension by continuity, involving a large part, and not infrequently the whole, of the bone. This destruction of the entire bone is sometimes found in the lower jaw. In all the cases I have seen affecting the upper jaw, the ravages of the disease were mainly confined to the alveolar arch.

The pathological anatomy of this form of necrosis deviates in several points from the typical history. In the first place, it is a progressive disease. It is not, as in the shaft of the long bones, an accident which happens, and is followed by changes whose object is to repair the damages inflicted by that accident. It is rather an active progress of diseased conditions from one point to another, leaving behind death as the result of the conditions, and extensive death as the result of the progress. In this respect it pursues a course strikingly like that we have seen in the spreading necrosis of the cranial bones, depending upon constitutional causes. The sequestrum, being largely cancellous and freely exposed to the air, becomes soaked with pus, which rapidly putrefies and, flowing down into the mouth, taints the breath with a horrible fetor, and poisons the stomach, into which a large quantity of this disgusting fluid must constantly find its way. It can hardly be doubted that a large part of the deplorable cachexia of the later stages of this disease is due to the inhalation and the ingestion of this decomposing and highly infective discharge, which no antiseptics can perfectly purify, and no attention to cleanliness can entirely prevent from doing its deadly work.

While these changes are going on in the bone, the periosteum and the surrounding soft parts become very greatly thickened and indurated, presenting a swelling of the face which greatly distorts the countenance, and presents to the touch a sensation as if an extensive and very thick involucrum were being established. Dissection shows, however, that this involucrum does not form while the sequestrum remains unremoved. The swelling is found

to be merely in the soft parts, and contains not a symptom of new bone formation. It is true that there is sometimes found, between the separated periosteum and the bone, a grayish, powdery material, of a calcareous appearance, which adheres at some points to the inner surface of the periosteum, and at others to the outer surface of the dead bone, from either of which surfaces it can be partly peeled and partly scraped away. At some points this substance seems to be organized into true bone tissue, as far as microscopic structure is concerned, and makes a sort of bony plate of new-formation, which doubtless represents an effort on the part of nature to form an involucrum; an effort which never seems to result in a complete, or even in a very extensive, success. The best specimen I have seen of this quasi-involucrum is depicted at Fig. 2449, from the New York Hospital Museum. If now to these statements we add the important fact that, as soon as the sequestrum is removed, the process of reformation begins, and goes on rapidly until a very perfect and a very useful jaw-bone is formed in the bed from which the old one was removed, we shall easily perceive that the whole process of sequestration and involucration was intended to be of a different type, and upon a different plan, from that which we have become accustomed to see in other parts of the skeleton. The immense brawny thickening that surrounded the sequestrum during its sojourn in the jaw was intended to fortify the bone while it was being separated, but was not intended to ossify into the replacing bone, as elsewhere, and for a reason which at least seems plausible. If the new bone was to be made out of the thickened tissues which cause the enormous swelling of the face, then it is evident that its ossification would have the effect of rendering permanent the hideous deformity which this swelling necessarily produces. In the tibia or femur this increased thickness is a matter of no cosmetic importance, but in the face any such increase in bone dimensions would be a serious, and in the present case a mortifying, result; which unfortunate result has been happily avoided by a change in the type of repair, such that, when all is favorably completed, the great thickening of the soft parts melts away, and the newly formed bone fills out the out-

Fig. 2449.

lines of the old so nearly that, without a careful scrutiny we could sometimes hardly appreciate the change which has taken place.

It must be acknowledged, however, that the degree to which this replacement takes place varies in different individuals. In one case of which I have records, the notes say: "The half of the jaw removed is replaced by firm bone, in which the angle of the jaw is marked, though not quite as acute as it should be, and the coronoid process is also clear. The whole new bone is a little smaller than the original, but is a remarkable imitation of it. The alveolar border is prominent into the mouth, and he can chew very well upon it." Fig. 2450 shows almost a complete reformation of a necrosed jaw. The specimen was taken from a patient of Dr. James R. Wood, and is in the museum of Bellevue Hospital. The newly formed parts are evidently smaller than the original bone. In another case, where the whole bone had been removed, the notes say: "Some months after the operation I saw him, and was surprised at the small amount of deformity. An ingenious dentist had adapted a pair of plates, with teeth to the absent jaw with great success. These plates rested on a firm cicatricial mass which occupied the place of the removed bone, but it was not certain that any deposits of bony matter had taken place." These cases rep-

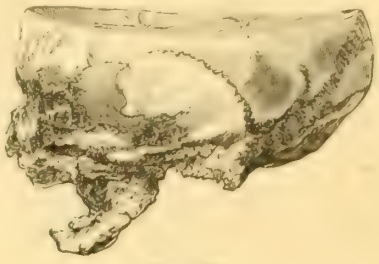

Fig. 2450.

resent the two extremes of restoration; and they have a further interest in that in the first or perfect restoration there was no attempt at the ossification of the involucrum, and in the second, in which no bony restoration occurred, there was noticed, at the time of operation, a very large deposit of the pumice-like material above described between the periosteum and the bone. These observations seem to strengthen the views expressed above, as to the significance of the various parts of the process of restoration; and they also suggest that, when there is found to be an abundance of the false involucral deposit, there will be a corresponding deficiency of ultimate bone reproduction; and, on the other hand, that the best examples of perfect bone reformation will occur in those cases which have shown no attempt at premature involucral ossification.

With regard to prognosis, it may be stated that the disease is rarely fatal. A most unfavorable feature is that, when once the poison has commenced its work, it will not relax its activity until the whole destruction it is capable of has been inflicted. There seem to be but few slight or self-limited cases, excepting so far as that the destruction is commonly limited to one half the bone, the second half, if affected at all, not being involved by an extension from the original, but from a new point of infection in the alveolar portion of the remaining bone.

With regard to treatment, nothing encouraging can be said during the first stages of the disease. No cleanliness, no antiseptics, no removal from the fumes of the poison, no surgical treatment, and no rigorous regimen seem to have power to stay the onward march of the destruction, and it is doubtful whether anything we can do by incisions, by drainage, or by local applications, has any influence in limiting the area over which it will finally extend its ravages. By all these devices, however, something will be gained, in checking fetor, in preventing accumulation, in draining away from the mouth by free external incisions, and thereby in mitigating the suffering and minimizing the constitutional depreciation so certain to follow in the later stages of the disorder. Of course, the clear indication is to remove the dead bone as soon as possible. This may be done piecemeal, or in successive operations, removing at each only the portions which have already perished; or the surgeon may quietly wait till he is satisfied that the sequestrum is entirely detached and loose in its bed, and may then be able to make a single and final operation. The advantages of the first method are that the excessive and poisonous discharge is greatly diminished at each operation where the dead bone is removed, and the patient has a respite from some of the most distressing features of his disease. If, on the other hand, the surgeon can make his patient sufficiently comfortable to permit him to wait, he has the satisfaction of performing a complete, final, and most effectual operation. Many of these operations can be done through the

mouth, as it generally happens that the alveolar sequestra project into this cavity, and when the separation is complete, a slight liberation of mucous membrane will often set free a very large sequestrum. Some cases, however, may best be managed by external incision, which should be made along the line of the margin of the jaw, and, if possible, a little behind it. The healing after the removal of the sequestrum is remarkably rapid, and the constitutional cachexia soon disappears when its provoking cause has disappeared.

Fig. 2451.

4. Necrosis after Fractures.—As a consequence of simple fractures, necrosis almost never occurs. In compound fractures some degree of necrosis may be said to be common. Two conditions of compound fractures lead to necrosis, viz.: first, fragments of bone so nearly separated by the accident that in the inflammatory conditions that follow they lose their vitality; and second, ends of bone so long exposed to the air and the putrefying discharges of an inflamed wound that they also die, to the extent to which they are exposed to these injurious causes. The fact of necrosis of either kind does not necessarily imply that union will not take place; the rule is that union does occur under these circumstances, particularly where the sequestrum is small and not directly interposed between the broken fragments. Often union occurs accompanied by the effusion of an excess of callus, which makes an involucral mass which sometimes so imprisons the dead piece or pieces that extrication is impossible without an operation. When, however, the sequestrum is quite large; when it lies in an unfavorable position, as in Fig. 2451; when its presence has excited abundant and long-continued suppuration, then we not infrequently find that union has been either altogether defeated or so imperfect as to be practically valueless. The most common form of this necrosis is shown in Fig. 2452, where the broken extremities, which are well approximated, have died from long exposure in a suppurating cavity. The death is seen to extend about an inch from the end of each fragment, and from the living bone in the immediate vicinity an abundant effusion of callus was thrown in a ferule-like form, bridging over the space occupied by the sequestra. In the figure much of the ferule has been removed to display the dead extremities; and it is evident that, if the processes of nature could have been completed, there would have been a loss of two complete inches of the tibia without any shortening, so perfectly did the ferule of new bone compensate for the destruction which had occurred within it. By contrast, the patient from which Fig. 2451 was taken lost his life in consequence of the interposition of the fragment seen, which was evidently an original one, and which, by its position, so completely disturbed the reparative efforts of the injured parts that almost no trace of union could be discovered beyond a single slender bridge that spanned the breach at one point, and which could never have afforded the slightest support to the broken bone. After a six months' trial an operation was performed, which revealed the condition of things described above, and the fragment was removed. No repair seemed to be excited by the removal of the dead bone, and the patient finally succumbed about four months afterward.

Fig. 2452.

Sometimes necrosis attacks one or other of the broken fragments in such a way as to indicate that an osteitis, produced in consequence of the original injury, has gone through its stages much as it would have done had no fracture existed. The presence of this necrosis seems in such cases neither to modify, nor to be modified by, the healing of the fracture (Fig. 2453).

The indication of treatment in each of these conditions is the same, and in all cases consists in the removal of the dead portions of bone. When the union is firm, the operation is required for the removal of a foreign body which keeps an open sinus and excites a discharge of pus as long as it remains; and where the union has failed, the best prospect of cure will be the removal of what, in nine cases out of ten, proves to be the cause of the failure. In these operations it is sometimes necessary to make extensive cuttings of the involucral mass which imprisons the sequestrum. If this is done carefully, not cutting transversely any more than is absolutely necessary, little or no injury is likely to be done to the newly formed bond of union, where that bond is well consolidated. Where no good union has taken place, the operation is usually an extremely simple and safe one, and consists in cutting through soft parts which overlie the dead bone, and removing it through as small an opening as will permit its exit. In both cases a good result is reached, and most commonly a perfect cure is achieved; and in those cases where union has only been hindered and delayed, it is noticed that the new traumatisms seem to have a happy effect upon the reparative disposition of the parts, and to excite a prompt and healthful action which soon terminates in a solid and permanent cure.

Fig. 2453.

5. Necrosis after Amputations.—As might naturally be expected, the sawed end of bone, in a stump which becomes the seat of inflammation and prolonged suppuration, is liable to become necrosed. This necrosis is usually limited to a ring surrounding the free end of the bone, and as it usually separates and comes away after a few weeks, and before the soft parts have entirely healed, it is an accident which only delays the sound healing of the stump until the surgeon can draw out the necrosed ring of bone. There is another form of necrosis in stumps, which is a much more serious matter. It is most common in the thigh-bone, but is occasionally seen in the humerus, and sometimes in the radius and ulna. The clinical history is about as follows: After an amputation through the middle third of the thigh, the healing of the wound goes on in the most satisfactory manner during the first few weeks, and then seems to come to a standstill. Certain points along the line of union continue to discharge matter in such quantity as to suggest some deep source of suppuration, and soon the orifices of these sinuses begin to show the pouting granulations indicative of the presence of a foreign body. Meanwhile the stump continues sore and painful to the touch, and seems swelled, particularly at its extremity. On feeling deeply, it is readily ascertained that this swelling is not of the soft parts, but of the bone, the end of which can be perceived to be enlarged, bulbous, and very sensitive on pressure. A probe passed in at any of the openings

detects dead bone. This condition has gradually come about without any assignable cause. No inflammatory attack has been experienced, and no unfavorable conditions have preceded this morbid state of the end of the bone; but gradually feverishness arises, at first occasional, afterward constant, a free discharge now flows from the sinuses, and the stump is hot, tender, and sometimes painful. The pathological condition is due to the death of a very considerable portion of the shaft of the femur, and it becomes an important question how that death has been brought about and how far it extends. If we cut down upon the face of the stump we shall find the end of the bone greatly enlarged, and a ring of bone corresponding to the saw cut in a condition of necrosis. If sufficient time has elapsed for its complete separation, the sequestrum will be found to consist of a tube of bone corresponding to the inner or medullary lamella, but which extends three, four, or even seven inches up the shaft, and which, by a little care in manipulation, can be drawn out of its bed unbroken. This tubular sequestrum shows, on its inner surface, the natural appearance of a bone macerated in the usual way, while on its external surface it shows the irregularities and roughness which are always seen where dead has, by absorption, been separated from living bone. Around the sequestral tube the bone has the involucral thickening which has been felt in the stump, and within the tube can sometimes be found a stem or axis which represents the medullary membrane which has taken on itself a more or less complete process of ossification, and forms a central plug reaching nearly down to the point of saw-cut (Figs. 2454 and 2455).

Fig. 2454.

The pathological facts given above are accepted by all, and the tubular sequestra as described abound in all our large museums. The explanation of their mode of occurrence is not so unanimous. Some authorities have considered that the injury done to the medulla by the action of the saw is sufficient to account for the resulting necrosis. That this injury may be the cause of the limited ring-like necroses so often met with seems highly probable; but it hardly seems likely that this traumatic influence could extend seven or eight inches up the shaft of the bone without being accompanied by such manifestations of medullary inflammation as could hardly fail to be recognized. Now, it is on record that these peculiar sequestra occur usually in stumps which have passed through the early stages of the healing process in a perfectly normal and undisturbed manner. This supposition is not sufficient, simply because it does not explain all the facts in the case. A more probable, and a more perfect, explanation of the phenomena appears to be afforded by referring them to the division of the nutritive artery, as it runs upward to supply the medullary membrane and the inner lamella of the bone. This artery may be divided before it has reached the nutritive foramen, or it may be divided in the long canal before it has begun its ramifications. In either case the result is the same. The inner lamella of the bone, to which this artery is principally distributed, is suddenly deprived of its circulation, without any chance for anastomotic temporary supply. The outer lamella, nourished from the periosteum, is not affected, but its capillaries, confined in unyielding bony walls, cannot dilate so as to meet the emergency, and the medulla, itself supplied from the severed artery, cannot render any immediate assistance; so that there is a varying period during which no circulation takes place in the inner lamella of the bone, and it is quite comprehensible that if this period of anæmia be too long continued, the death may take place of a certain portion of the districts of the bone involved in the deficiency. In such a case the necrosis takes place quietly, without any signs of inflammatory commotion, and without any interference with the healing of the amputation wound. After the lapse of a certain time, however, the dead mass within the femur begins to act as a foreign body, and gradually, and more and more emphatically, it announces its presence in the stump by the symptoms already detailed.

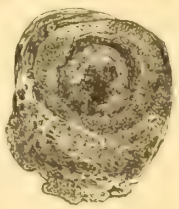

Fig. 2455.

The treatment of these sequestra consists in waiting until they are loosened in their bed, and then removing them. The peculiar shape of the upper end of the sequestrum, its slender branching extremities with their exceedingly irregular outline, makes it difficult, without the greatest care, to extract them unbroken, even when they are perfectly loosened. Of course, if separation be not complete, some part of these delicate points will be broken off and left in the depths of a wound from which their extrication can only be effected by the slow process of natural extrusion. It has happened that in attempting to remove one of these tubular sequestra, it has started from its bed, showing that separation was complete; but after yielding a half inch, or even an inch, it has been held so fast as to defy any power of traction that could be brought to bear upon it. This has been found in one case to be due to a spur of bone growing through a hole in the sequestrum, and consolidating the outer with the inner cylinder of involucrum, and in this manner holding the sequestrum in its place as if it had been nailed there.

In the progress of necrosis there are certain dangers which threaten the patient, which it is important to recognize, and some of which may come upon us so suddenly as to call for the most prompt, intelligent, and sometimes courageous, interference. These dangers lie chiefly in three directions. First, we find that the joints nearest to the diseased point are apt to become affected, and sometimes seriously compromised. Second, the patient may be reduced to an alarming condition of constitutional feebleness by the irritation of the nervous system and by the profuse discharge. Third, hæmorrhage, sudden, uncontrollable, often fatal, may occur without warning and without apparent explanation.

With regard to the first of these dangers, viz., invasion of joints, it must be remarked that there are two ways in which this invasion occurs, one slow and gradual, the other acute and rapid. The slower involvement of the joint means gradual stiffening and adhesion of the various joint elements, so that a more or less perfect anchylosis is finally produced; while the sudden form usually signifies acute, and often destructive, inflammation of the joint structures, from the fatal consequences of which amputation or excision offers the only chance of escape. The first, or gradual form, is seen in almost every case of necrosis of the lower part of the femur, or of the upper part of the tibia, so that the knee-joint is the one claiming most of our attention in this respect, the hip- and the ankle-joints being not nearly so often nor so seriously affected. The joint gradually grows stiffer and more painful on motion, until finally it becomes so absolutely rigid that no movement is permitted, and then little or no pain is felt in bearing weight on the limb. This condition seems to be brought about by a slow spread of the inflammatory actions which are occurring in and around the involucrum, and it does not seem clear how they can be prevented from doing the threatened mischief while these central actions are going on. Perhaps by some gentle counter-irritant, like the tincture of iodine, something may be done to diminish the effects of the inflammation, and combined with careful and judicious passive motion and massage, may save some of the ultimate usefulness of the joint. The main indication, however, to be drawn from this tendency to joint-stiffening, is that the operation for removal of the sequestrum should be delayed no longer than is absolutely necessary.

The second, sudden form of joint-invasion, is very much more rare, and almost always occurs in cases where the cancellous tissue of the joint ends of the bone is in-

volved in carious inflammation, in connection with which necrosis of parts of the articular lamella has occurred, and the sequestrum looking into, and perhaps finally falling into, the joint, has determined its destructive inflammation. This is not the only way, however, in which joints are directly destroyed in necrosis. We have in the New York Hospital Museum a specimen showing the results of a destructive inflammation terminating in a complete bony anchylosis of the knee-joint, as the evident consequence of the passage across its posterior portions of a large, sharp-edged sequestrum, which has pushed its way down through the popliteal space, and by opening into, has destroyed the joint. Again, all sequestra which involve the articular lamellæ do not destroy the joint. Sometimes the inflammatory actions excited by the presence of the dead bone are shut off by limiting fibrin from the rest of the joint, which thus escapes destruction. Of this we have a beautiful exemplification in the museum, occurring in the lower end of the tibia, in which a considerable sequestrum involving the articular surface has separated, leaving the remainder of the joint unaffected. Finally, in the progress of caries affecting the joint-ends of bone, there are occasionally found small fragments which have been detached from the ulcerating bone surfaces, and which are not large enough to be called sequestra, but which, particularly if there be several, are quite sufficient to prevent a cure of the disease, and to hurry on the joint to certain, though perhaps gradual, destruction.

Secondly, the disease may, through excessive discharge and long-continued suffering, seriously compromise the patient's general health. In a large proportion of cases of uncomplicated necrosis, even though the disease be extensive and the sequestrum large, after the first weeks of inflammation and fever the health is regained, and the patient carries about with him a foreign body in the shape of a detached sequestrum which, though it be a great local annoyance, does not impair his general health, nor very greatly interfere with the functional activity of the affected limb. There are, however, cases in which this favorable progress is not realized. The inflammatory and feverish symptoms do not completely subside, the discharge does not diminish, but becomes more abundant and more watery and sanious. The appetite begins to diminish, the red corpuscles in the blood to disappear, the nutrition to fail, emaciation steadily to increase, until after the lapse of a few weeks or months hectic is developed, and the case is rapidly hastening toward a fatal termination. It is not, however, so much the apprehension of a fatal issue, for in uncomplicated necrosis such a result must be rare, but rather the fear that during this disturbed constitutional condition the reparative forces will prove inadequate to form the involucrum, as it should be formed, to be an effective substitute for the dead bone which has separated. This failure becomes more important when it is remembered that, if full regeneration of bone does not take place promptly and at the proper time, the likelihood is very great that it will never take place at all; or, if some secondary and later attempt at involucration should occur, the result will be imperfect and inadequate. Of this failure to perfect the involucrum our museums present multitudes of examples, and in looking at some of these specimens it is easy to see how perfectly useless a limb may be rendered by even a partial defeat of this important process of bone replacement. One very perfect example of this deficiency of involucrum is seen in Fig. 2456. In this case the young man had suffered greatly during many months of the earlier stages of the disease, and when finally the sequestrum, involving almost the whole of the shaft of the tibia, was removed, there was to be found nothing to replace it except a tolerably strong fibrous cord, in which were some small spurs and nodules of bone, not continuous and, therefore, not affording the slightest help in supporting the limb. A most interesting fact is illustrated by the specimen, in the hypertrophy which the fibula has undergone, intended to make up for the loss of support by the tibia. He lived several months after the removal of the sequestrum, and was able to bear a little weight on the limb, which was growing stronger and stronger, until he was laid up by his fatal disease. Comparison of the two limbs shows that the fibula on the diseased side has acquired a thickness at least three times as great as in the normal bone, thus presenting a remarkable example of simple compensatory hypertrophy.

How this second danger of constitutional exhaustion is to be met will probably be suggested by a careful observation of each particular case. General nutritive tonics will, of course, be indicated, and the most wholesome and invigorating regimen insisted upon. The limb should not be kept too long functionally inactive, and the most perfect local conditions as to free openings and thorough drainage should be secured. Beyond this little can be done, except to remove the sequestrum as soon as it is separated; and, perhaps, it might be justifiable, if the discharge were profuse and ill-conditioned, to cut away the sequestrum before the process of separation is complete, with the view

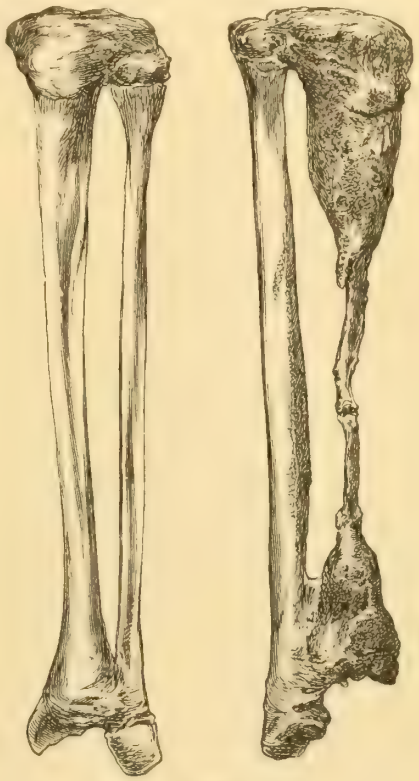

Fig. 2456.

of getting rid of the irritating effects of its presence as a foreign body within the wound. After such removal, and as soon as the reparative efforts are established in the wound, the limb should be gently exercised as it is able to bear it, so that the compensatory effort which has failed in the first instance may be provoked again by the returning use of the limb.

The third danger, that of hæmorrhage, is sometimes truly formidable. In studying the history of the process of separation, it was stated that there was a tendency to extrusion of the sequestrum precisely analogous to the forcing of pus, or of foreign bodies, toward the surface, when these are lodged in the soft parts. This tendency would show itself more distinctly, and would be more often attended with success, if the sequestrum were not imprisoned so closely in its bony case that it cannot be moved. When, however, as does occasionally happen, the involucral covering is deficient or incomplete, then we do find the sequestrum pushing itself in the direction of the least resistance, to find the surface as it best can. It is in these excursions of a rough or sharp-edged se-

questrum that we find the sides of arteries pressed upon and worn through, till the cavity of the vessel is reached and blood begins to flow out.

The clinical history of these cases is often very misleading. The first thing noticed, perhaps, is a slight bleeding from the sinuses leading down to the dead bone. This in itself is not a very serious matter, for it often happens that some movement of the sequestrum, as in jumping or running, or some congestion of the capillary circulation of the granulations, as in long standing or in lifting heavy weights, may give rise to a considerable outflow of blood from the granulating surface, which never reaches a formidable amount, and stops of itself as soon as its exciting cause is removed. In the cases now under consideration, however, the bleeding soon recurs, and now it is a sudden, active outrush of blood, which lasts perhaps a few minutes, and then again ceases of its own accord. This is the deceptive feature, and sometimes the arrest of blood may last several hours, or even days, and the surgeon begins to flatter himself that there is no danger. He is not long in being undeceived. Another more profuse hæmorrhage takes place, only to prepare the way for others more violent and more rapidly recurring, till life is either suddenly extinguished by the greatness of the loss, or is reduced to so low an ebb that no surgical promptness or skill can save it.

The explanation of this terrible history is simple enough. The advancing sequestrum has by steady pressure worn a hole in the side of a considerable artery. The small vessels, through which it has passed, have been sealed by a plug of fibrin before their coats give way, and no mischief has been done, but now the side of a large vessel is perforated, and some blood escapes from the opening. A plug of coagulum stops the outflow for a time, until the hole in the vessel's side grows larger, and then other hæmorrhages take place, more and more severe as the opening grows larger, until no coagulum will stop it, and it hurries the patient to his death.

That this statement of the formidable nature of hæmorrhage in some cases of necrosis is not too strong will appear from the fact that, of eleven cases of this form of hæmorrhage in necrosis treated or seen by me, during the period of twenty years, most of them in the wards of the New York Hospital, six have died. This mortality, under circumstances favorable for prompt and skilful assistance justifies the most alarming prognosis, and suggests that promptness in recognizing the danger and courage in attacking it, is the only hope of saving a life so imminently threatened.

Of eleven cases seen during life and examined post-mortem, and of two examined post-mortem, but not seen during life, I have found that in every case it was the main artery of the region that had been opened by the extruding sequestrum. One case could not positively be ascertained to have occurred as above described, but we found the main artery eroded and a sharp spiculum of bone, which might have caused the opening, but the edge of bone was not in such a position as to convince us that it was certainly the cause of the mischief. Thirteen such observations are certainly not enough to establish a positive pathological law; but it seems to me that the uniformity of the testimony they afford is quite sufficient to suggest a safe clinical rule—that wherever repeated, unexplained, and rapid hæmorrhages occur in a case of advanced necrosis, we may believe that a main arterial trunk has been injured, and be guided, both in our prognosis and in our treatment, by this unpromising view of the case. The prognosis, of course, must be grave. The treatment must be unhesitating and courageous. One single object must be in the surgeon's mind, to reach the seat of the bleeding and effectually to stop it. In doing this the removal of the sequestrum is a secondary matter. If it be convenient and does not occupy too much time, get rid of the sequestrum before you seek the wound of the artery. But if the sequestrum does not admit of prompt and easy removal, do not waste time upon it, but proceed to secure the artery by a well-placed ligature, and then you have leisure to proceed, in the best way and without being hurried, to remove the sequestrum. This search for the wounded artery will not always—perhaps I ought to say will not often—be successful. The parts are so distorted by the inflammations which have been so long in progress in and about the involucrum; the bone deposits make it so hard to identify anatomical landmarks, that it is sometimes a tedious and difficult task to find, and much more to ligate, the injured vessel in the wound. If the apparent position of the wound and the condition of the soft parts will permit, such an attempt should be made, and not lightly abandoned. If, however, the bleeding point be entirely uncertain, if the surrounding soft parts are in a condition of extensive inflammatory infiltration, then the question lies between ligature of the main trunk above the lesion, or amputation. That ligature above the wound may be occasionally successful, I do not pretend to assert or deny. But when we remember how little sure we can be that such a ligature will not be followed by distal hæmorrhage, and when we remember how poorly our patient is prepared to endure further loss of blood, and when, still further, we take into consideration the damaged condition of the limb, and how prone such a limb might be to the various accidents following the ligature of its main artery, we will, I think, not often find ourselves impelled to adopt that course of procedure. It has so happened that in all the cases that I have seen, both in my own practice and in consultation with some of our most eminent surgeons, this method has not been recommended, and, as far as I now recollect, has not been proposed. Of its results, therefore, I cannot speak from my own experience.

In a case, therefore, in which it seems unwise or impossible to secure the artery at the point wounded, amputation becomes the only resource. It is a mortifying alternative, and one which naturally causes the surgeon to hesitate. It is nevertheless the clear indication, and any hesitation in deciding, or delay in executing the operation may be fatal.

The Treatment of Necrosis, in its usual manifestations, may be studied under three indications: First, to prevent or relieve the inflammation which is about to terminate in death of bone; second, to promote the separation of the dead from the living bone; third, to remove, or facilitate the removal of, the sequestrum.

So many of the cases of necrosis which ordinarily come under the care of the surgeon in the earliest stages of the disease, are, in those early stages, only cases of inflammation of the bones or their periosteum, that we have reason to think that by prompt and vigorous treatment we may sometimes, by curing the inflammation, prevent the necrosis. According to its extent and locality, this threatening osteitis may be attacked with leeches, hot fomentations, blisters, and all our active remedies against acute inflammation, of course combined with rest and a strict antiphlogistic regimen. Where the disease is localized, limited in extent, and accessible, as for example in a whitlow, much can undoubtedly be done, if undertaken early, to arrest and even abort the inflammatory process, and thereby save the part from disorganization. In more extensive, less defined, and more inaccessible cases of threatening osteitis, as in the tibia and femur, much hope cannot be entertained of controlling absolutely the progress of disease, but much can be done, if the disease and its dangerous tendencies be early understood, to mitigate the severity, and therefore the dangers, of its progress. This can be accomplished by ordering the patient at once to his bed, and placing the limb in an elevated position, where it should be secured by some simple arrangement that would prevent unnecessary movement, making such local antiphlogistic applications as seem to promise best, and placing the patient on the regimen and diet most adapted to carry him through the sufferings and dangers which are before him. In the cases now supposed, moderate local depletion is admissible, but should not be carried too far, lest, by reducing tone, both locally and generally, we favor the occurrence of the accidents it is our purpose to avoid. Cooling evaporating washes, or hot fomentations properly applied, certainly will soothe some of the suffering, if they do not materially arrest the

progress of the disease. The abscess should be opened early and the exit of matter secured by drainage tubes, through which, once a day, injections may be made, carefully and without force, of some mild antiseptic solution, as the bichloride of mercury, or carbolic acid—of the first say 1 to 5,000, and of the second two parts to the hundred. After the abscesses are freely discharging, and when the local symptoms are greatly relieved, the patient may be allowed to leave his bed, and may gradually be allowed to use the limb as he is able to do so. In many instances the patients are able to use the limb as freely as ever during most of the period of sequestration and separation, and I am disposed to encourage them so to do, as moderate exercise, even of a diseased limb, favors normal nutrition, and undoubtedly improves reparative capacity. If, during this period of separation the discharges continue profuse, it may well happen that all our efforts must be directed toward sustaining and building up the general health, by tonic and nutritive medicines, by the best food that the stomach will tolerate, by change of air, and by all the well-known methods in which we try to maintain and increase constitutional reparative power.

The questions present themselves, supposing sufficient time has been allowed for the processes of sequestration and involucration to be fully completed, what shall be done with the sequestrum, and what is the best time to operate? The answer to these questions is, first, that the sequestrum is to be removed as soon as it is loose, and second, that the only way of being sure of the process of separation being complete is by exploration with one or more probes. Placing one probe in a sinus, for example, at the lower part of the region in which the sequestrum is supposed to be, and another at the upper part of the same region, and making the end of each probe touch the surface of the sequestrum, and then exerting pressure alternately on the two probes, we can, if the dead bone be very loose, easily discover a yielding under the pressure, and a movement which is a certain proof of the entire detachment of the sequestrum. It may sometimes, however, be quite impossible to feel sure that any movement of the bone takes place when we employ the ordinary probe in our examination. It may be that the bed of granulations, in which the sequestrum lies, embraces it so closely, and holds it so firmly, that no motion can be impressed upon it by the force which the probes will bear. Under these circumstances I have used two small, straight, steel urethral sounds, and by pressing on them firmly, and continuing the alternate pressure first on one and then on the other, I have been able to sink the sequestrum, as it were, in its fleshy bed, and soon to develop a perfectly distinct evidence of motion. It may be, however, that in some cases we cannot avail ourselves of this method of ascertaining the mobility of the sequestrum. The sinuses may not be well situated, the dead bone may be too far from the surface, the sinuses may be not direct, and thus we may fail to get the information we seek. We are then reduced to the element of time. If in any given case sufficient time has elapsed to render it probable that sequestration is complete, we are justified in proceeding to an operation, which in such a case of doubt ought to be merely explorative. We can usually, by a moderate incision, and perhaps a few strokes of the chisel, come down upon some part of the sequestrum near enough to be sure whether it is movable or not. In case we find it loose, we proceed at once to the operation for its removal, while if we are assured that it is not yet movable, it is generally the part of wisdom to wait a few weeks longer, until the separation has become complete. The surgeon may, however, sometimes decide to remove all dead bone that is accessible, although it be not separated, and will thereby diminish excessive and exhausting suppuration, and relieve, perhaps, other trying symptoms which the presence of the large sequestrum has provoked. The remaining, still attached, portions of the dead bone will often come away without further operation. The time to be allowed for the completion of the process of separation cannot, of course, be positively fixed. I have generally thought it best, in large sequestra of long bones, to allow at least three months before operation. Smaller sequestra, in young and vigorous patients, will separate in a much shorter time.

Having now settled the question as to the propriety of operation, the time of its performance may be considered. As a general rule, it is better to remove the sequestrum just as soon as it can be ascertained to be loose. But if the patient be much reduced in health, if the season be unfavorable, and if the discharges and the sufferings from the local disease be not excessive or exhausting, then it is quite proper, and generally quite safe, to wait until, by careful attention to nutrition, by fresh air and exercise, perhaps by change of air and surroundings, we secure a better reparative condition of the system, in view of the often serious operation which is contemplated. If there be no considerations of this nature, the operation should be undertaken without unnecessary delay.

The operation itself consists in releasing the sequestrum from its mechanical confinement within the tissues, and removing it. The operative procedure will vary, therefore, with the extent and solidity of the tissues enclosing the sequestrum, and with the accessibility of the sequestrum from the surface. In most cases of superficial necrosis, or exfoliation, it is only necessary to divide the soft parts covering the dead piece in order to remove it with great ease. This, however, is not always the case in exfoliation, for it sometimes happens that the dead plate extends on the sides of the bone far from the surface, and it occasionally occurs that a thin plate of superficial necrosis surrounds completely certain portions of the shaft of the bone, thus producing a condition of things which renders operation extremely tedious and severe, and, not infrequently, even then the entire removal of the deepest portions of the sequestrum is not accomplished.

To take a typical case of necrosis of the shaft of the tibia, where the diagnosis is clear, the involucrum sufficient, and the sequestrum entirely separated, the steps of the operation may be described as follows: A free incision is made on the anterior surface of the limb, where the bone is most superficial, and this incision should extend as far as the supposed limits of the necrotic action, and may be crossed by another at about its middle, so as to give easy access to the surface of the involucrum. The flap then being dissected up clean from the exposed bony surface, we select the most favorable point for attacking the bone-case enclosing the sequestrum. This is generally to be found at one of the larger cloacæ, which being further enlarged by the chisel or gouge, soon gives us access to the cavity in which the dead bone lies. By means of this first exposure of the cavity we learn the size, the degree of freedom, and the extent of the sequestrum, and we take our measures accordingly. If the sequestrum prove to be very long, then the incision through the involucrum must be extended so as, if possible, to release it without breaking off any of the irregular and slender processes in which it terminates. About this the operator should be extremely careful, as, if any of these fragments are left in the bottom of the wound, they are apt to give trouble, and if we cannot reach and remove them with slender forceps they are frequently a long time in making their way to the surface, during which time, of course the wound will not heal. In exposing one of these large sequestra, it should be borne in mind that restoration of the involucral bone which we are cutting away takes place to only a very limited extent, particularly in those who have passed the earlier periods of life. It must be remembered that nature has already, in forming the involucrum, accomplished a very elaborate and extensive restoration of bone, and if we destroy this new-formation she will hesitate about repeating the process. In point of fact, we find that the cavity left after these operations does not, except in very young subjects, fill up with bone, but rather with a firm, fibrous, cicatricial tissue, which, while it fills up the gap left in the bone, contributes very little to its strength. We must be careful, therefore, not to weaken the bone by any unnecessary cutting in its transverse diameter, though in the longitudinal we may proceed with more freedom. The

cutting is done most satisfactorily, I think, with a gouge, though if a cloaca is not in a favorable position for enlargement a small trephine answers a good purpose in making the first opening through the involucrum. The gouge and the rongeur, however, will be all that in most instances will be required. After the removal of the sequestrum a careful examination should be made with the finger and the probe, to make sure that no fragments remain, and that no cavities are left without sufficient openings to secure drainage.

The after treatment of the wound is the simplest possible. The skin-flaps are laid together without any attempts to bring them in close apposition, and the wound is lightly stuffed with iodoform gauze. As the healing of the wound must be by granulation, no other dressing is usually necessary. With a view of diminishing the extent of the wound to be healed by granulation, some of the German surgeons have suggested the idea of turning the skin-flaps down into the deep cavity, and nailing them to the bone by means of silvered steel nails, which are removed when adhesion has taken place. How much this might diminish the area of wound repair I cannot say, not having had any experience with the method, but it seems reasonable, and is reported upon very favorably by those who have made trial of it. The process of filling up the deep bone cavity by granulation is necessarily slow. In patients who are no longer young, months may elapse before the wound is entirely closed; in children and young adults the healing is more prompt. In any case, however, there will remain, after the cicatrization, a deep depression which, for the reasons given above, nature seems incompetent to obliterate. On examination and maceration of such a bone, years after the healing, it will be found that the gap has really been filled up by fibrous tissue rather than by bone. A slow process of modelling takes place by which sharp edges and projecting points are smoothed off, and some of the involucral thickening disappears; but the deep scar in the bone always remains to testify to the serious damage which the part has received.

Thomas M. Markoe.

NEMATODES are thread-like or round worms, having slender or even filamentary bodies without segments or appendages; the skin is thick and elastic; it sometimes has prominences or bristles; the mouth is at the extremity, and is sometimes soft, in other cases it has horny lips, or even jaws and teeth. The intestine usually extends from the mouth to the anus in the posterior part of the body; in some cases there is neither anus nor intestinal tract. The sexual organs and their openings, as well as the anus, are on the abdominal surface. The female opening is usually near the middle, while the male organ is near the anus and is often surrounded by horny rods, which, during copulation, enter the female opening. The male is much smaller than the female. The time required for the development of the worm after impregnation is variable. In some, as in trichinæ, the process is completed in a day or so; in others it may be months before the embryo is perfect, as in ascaris lumbricoides. There are endless variations between these.

It has seemed to the writer as if there might be some practical advantage in grouping together the worms of this class, thus enabling the searcher more readily to compare different varieties.

There are perhaps a thousand varieties of round worms. Only those more or less frequently infesting human beings are mentioned here.

The nematodes which are found as parasites in man may be classed in four families: (1) ascarides, (2) strongylides, (3) trichotrachelides, and (4) filariæ. In the first are ascaris lumbricoides, oxyuris vermicularis, and ascaris mystax; in the second are eustrongylus gigas, strongylus longevaginatus, and dochmius duodenalis; in the third are trichocephalus dispar and trichina spiralis; and in the fourth dracunculus medinensis and other filariæ.

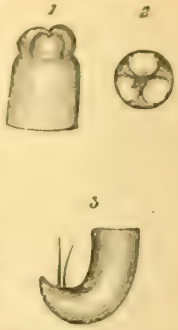

Fig. 2458. — Ascaris Lumbricoides. 1, Head from side; 2, head from above; 3, tail of male. (Heller.)

Ascaris, plural ascarides, is the name given to a group of nematode worms, of which three varieties have been found infesting human beings. The commonest and largest of these is *Ascaris lumbricoides* of Linnæus (lumbricoid or round worm). This has been known at least two thousand years. Aristotle gave these worms the name of *στρογγυλος*, while he called the oxyuris *ἀσκαρις*. The present classification is that of Linnæus. Leuckart says there are about two hundred varieties of ascarides known at present. In appearance it resembles the common earth-worm. The males are from four to six inches (150 mm.) long, the females from ten to fourteen, or even eighteen inches (400 mm.). They are pointed at both ends and have a three-lobed mouth. The tail of the male has a double spiculum, or penis. In the female the reproductive orifice is near the centre of the body. It has been estimated that one female may contain sixty millions of eggs. It is supposed that these do not develop for a long time after being passed with the fæces, and they resist changes in temperature and other adverse influences very well. The mode of development of the embryo and its manner of entrance into the human body are little understood; but it has been suspected that contamination of drinking-water from privy sewage may be the chief means by which the embryo gains admittance to the intestinal canal. It is not known whether this transfer occurs while the embryo is in the egg or after its escape. If any intermediary host is required, the embryo can certainly make but little progress there, while its development in the intestine of man proceeds rapidly.

The round worm inhabits the middle part of the small intestine; there are usually a number together, and this number may be enormous; one thousand are reported to have been found in the intestine of one patient.

Ascaris lumbricoides also infests the pig and beef; it is found in all countries, but is particularly abundant in warm climates; dryness does not destroy the eggs or prevent the development of the embryo.

Nothing definite is known about the age to which the round worm may attain; but it probably does not live over a year in its host.

Cobbold has watched the development of the contents of the egg to the embryonal stage in fresh water, and kept the embryos alive for three months; but experiments of propagating the worm by feeding the eggs to animals have proved unsuccessful. The hypothesis that they are introduced by means of drinking-water would be supported by the observation that they are more frequent in the country than in the city, and among those who are careless in their habits.

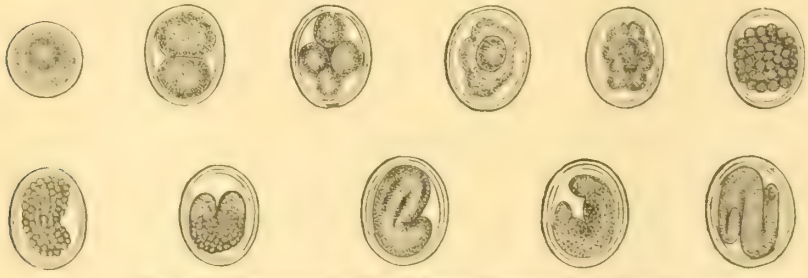
Fig. 2457. Development of Egg of Ascaris Lumbricoides. (Heller.)

A few round worms in the intestines would probably cause no symptoms; when more numerous they induce

itching of the nose, colic about the umbilicus, distended epigastrium, disturbed appetite, salivation, and mucous or even bloody movements from the bowels; sometimes there are puffiness of the face, darkness of the eyelids, unequal pupils, bad breath, emaciation, and nervous symptoms, such as irregular pulse, dreams, gritting of the teeth, etc. But worms are so often present that doubtless many symptoms are referred to them for which they are blameless. The only sure diagnostic point is seeing the worms or finding their eggs in the fæces. It is doubtful whether the worms ever become so massed during life as to cause obstruction of the bowels. It has been thought that some of the symptoms ascribed to worms were due to a peculiar acrid matter excreted by them; this is probably of an oily nature, as it is extracted by alcohol. Cobbold states that various observers have had unpleasant irritation of the conjunctival and bronchial mucous membrane, from examining lumbricoids.

Round worms occasionally wander into other cavities connecting directly or indirectly with the intestines, as the stomach, œsophagus, nose, larynx, Eustachian tubes, pancreatic and biliary ducts, peritoneal or pleural sacs, bladder, etc., and in the subcutaneous tissue they may be found in "worm abscesses;" these have been noticed especially in the umbilical and inguinal regions, which points correspond to the most frequent locality of hernia in children and adults. But what share the worms have in the production of the abscess is undetermined.

In the treatment of round worms, santonin, or some of its compounds, is the most successful remedy.

As we do not certainly know the mode of entrance of the parasite, the only prophylactic measure to be suggested is to be careful of the drinking-water. We should have it filtered or boiled, and should pay great attention to cleanliness.

Fig. 2459.—Ascaris Mystax. *a*, Natural size; *b*, head magnified. (Heller.)

Ascaris mystax is the round worm of the cat and dog. Cobbold reports having found it in children. The male attains a length of six centimetres (2½ inches), the female twice that length. It has two wing-like appendages placed at the side of its head like a hood. The eggs are somewhat smaller than those of A. lumbricoides; the embryo requires three or four weeks for its development. It is not known how these worms gain entrance into the intestine, but probably the eggs are licked from the hair of the animal, or children get them on their fingers and thence into their mouths.

Leuckart found embryos from 0.4 mm. to 2.0 mm. in length in the stomach of a cat. In the small intestine, when they have attained a length of about three millimetres, they cast their skins, and instead of a boring tooth acquire the three lips peculiar to ascarides.

Cobbold says that Nelson studied the subject of the impregnation of the nematodes in this worm; from his observations he thought that this occurred when the thimble-shaped spermatozoa penetrated the unimpregnated or ovarian ovum.

Owing to its smaller size, the symptoms induced by this worm would be less marked than those from A. lumbricoides. The treatment would be the same.

Ascaris maritima is described by Leuckart, from the examination of one specimen from Greenland, as being ⅝ inch long by $\frac{1}{75}$ inch broad.

Oxyuris vermicularis is a nematode worm of the family of ascarides; it is one of the most frequent of parasites, being found in all climates; it infests especially the cæcum, and is more frequently found in children. It is often called thread-worm, seat-worm, or pin-worm. It is cylindrical, small, white, and tapering at the ends. The mouth, closed by three small nodular lips, leads to a digestive tube terminating in an anus near the tail. The male is three to five millimetres long; the tail is rather blunt and curved anteriorly; the excretory duct from the testicles terminates in a hook-like penis at the anus, very near the end of the animal.

The female is nine to twelve millimetres long; the anus is at the commencement of the tail, the vulva in front of the middle of the body; when the uterus is full of eggs it distends the whole body.

Fig. 2460. Oxyuris Vermicularis (natural size). The larger worm is a female, the smaller ones are males. (Heller.)

This parasite completes its course from egg to sexual maturity in the alimentary canal of the same person. An egg introduced into the human stomach is hatched in a few hours; the young worm then passes to the small intestine and soon shows the difference between the sexes; the place where union of the sexes occurs, and where the worm most commonly dwells, seems to be the cæcum; but the worm may be found at any point from the upper part of the small intestine to the anus; it may be present in immense numbers.

Leuckart and Cobbold say that if the eggs be placed in a moistened envelope and exposed to the sun's heat for a few hours, they become worms. Three enthusiastic pupils of Leuckart swallowed some oxyuris eggs, and in fifteen days found the young worms in their stools.

Heller says that the eggs live but a short time in water, and hence excludes this as the medium in which they enter the human body; but they live after being dried. The general impression seems to be that they are taken up by the finger-nails or hands from the parts about the anus and thus conveyed to the mouth, or else are placed on food or something which is introduced into the mouth of another person. The excessive itching and consequent scratching of the anus induced by oxyurides increases the chances of getting them on the hands. From their very small size they may be mixed with meal, especially if coarse ground.

These worms are found in individuals of either sex or of any age, but are more frequent in women and children; they may continue to infest the patient for a lifetime.

Although existing throughout the intestines, and especially in the cæcum, it is only in the rectum that they induce symptoms; here they may cause excessive itching. In females they may enter the vulva and vagina, and cause just as annoying itching, perhaps leading to masturbation. In males they may lead to excessive venery or involuntary emissions.

This disease may be suspected when there is much itching about the anus, or when children handle their privates; if the worms are not seen on examination they may be secured by a small enema given when there is itching; eggs may be found microscopically by scraping a little mucus from the rectum and mixing with a three-fourths per cent. solution of salt.

The disease is often difficult to cure, because the medicines given are absorbed in the small intestine before coming into contact with the worms in the cæcum. It is well to give laxatives and wash out the intestines, and if the case is very troublesome a large enema may be given by Hegar's method, with the patient in the knee-elbow position. This enema should be of a saline or soapy solution, as plain water is apt to irritate.

If the worms are gotten rid of, reinfection should be guarded against by great cleanliness of the hands and finger-nails.

Eustrongylus gigas is the largest known round worm or nematode; the female may attain the length of one metre (39 inches), the male 400 mm. (16 inches). The mouth is six-sided and surrounded by six papillæ; during life the worm is reddish in color. The male organ is a small spicule, often projecting from the cloaca, surrounded by a cup-shaped bursa having papillæ along its edges. The female sexual opening is found about 70 mm. from the cephalic end. The history of the development of this worm is not fully known, but its larvæ probably exist in certain fish. The worm has been found in the wolf, dog, fox, and more especially in the mink; in a few cases it

has been found in man. Its usual location is in the pelvis of the kidney, so that the larva, when introduced to the stomach of the host, must be by size or physical characteristics suited to make its way to that location.

The diagnosis would be rendered possible only by the discovery of some of the eggs in the urine, in a case presenting symptoms of kidney disease.

Strongylus duodenalis (*Dochmius* or *anchylostomum duodenale*) is a cylindrical worm with a hard mouth, supplied with six hook like teeth, a muscular pharynx, and an intestine which often contains blood. The male is from 6 to 10 mm. ($\frac{1}{4}$ to $\frac{2}{5}$ inch) long, the female 10 to 18 mm. ($\frac{2}{5}$ to $\frac{7}{10}$ inch), with a conical tail; the sexual opening lies just behind the middle of the body. The eggs are oval, and 0.05 mm. in length. Cobbold says "the mode of reproduction is viviparous," while Heller says: "In them (the eggs), in twenty-four hours, in moist places, worm-like embryos develop and creep out, and under favorable circumstances may live free for some time and, shedding their skins from time to time, grow larger. The subsequent development is unknown." It is not known how man acquires this parasite, but from observations of Leuckart on dochmius trigonocephalus, which infests the dog, it is probable that the human dochmius passes its youth in a leech-like stage in dirty water, and with this enters the intestines. Its habitat is the lower part of the duodenum (whence its name) and the jejunum. By its head it adheres like a leech between the transverse folds of the mucous membrane. There may be only a few or as many as a thousand in one patient. There is one male to about three females. This parasite is found chiefly in Italy, Egypt, and Brazil. It is considered as the cause of a certain form of chlorosis, which is frequent in these countries, also of cases of anæmia found among miners. It induces this not only by the blood it sucks from the intestines, but by the bites continuing to bleed when it changes its position. The symptoms are paleness, fatigue, disturbances of digestion, palpitation, and bruits in the jugular veins, while the fat about the body is not lessened; the spleen is not enlarged, and both it and the liver may even be smaller than normal; fever is rare. The duration of the disease varies from weeks to years, depending greatly on the number of parasites present.

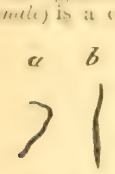

Fig. 2461.—Strongylus, or Anchylostomum Duodenale (natural size). *a*, male; *b*, female. (Heller.)

The diagnosis depends on the symptoms, as anchylostoma or their eggs have not been found in the dejections; perhaps a careful microscopic examination might detect the latter, which would much resemble the eggs of oxyuris vermicularis, but would be more intimately mixed with the fæces, as they come from a point higher up in the intestine.

As the anchylostomum lives upon the blood of its host, not upon the intestinal contents, the remedies would have to act through the blood or else poison the worm by coming in contact with its skin. The remedy used for it in Brazil, with asserted success, is the juice of gammeleira (ficus doliaria), and Griesinger advises calomel and oil of turpentine. In addition to these, tonic remedies are required. Griesinger estimated that one-fourth of the inhabitants of Egypt, where he was living, suffered from anchylostoma.

Trichocephalus dispar or *whip-worm*, formerly improperly called *Trichuris* (the head being regarded as the tail), belongs to the class of nematodes. The head and neck, comprising nearly two-thirds the length of the worm, are thread-like, with a longitudinal band of minute papillæ on the under surface, which perhaps aids it in retaining its position in the bowel. The body is about 1 mm. thick: that of the male is curved on itself, while that of the female is nearly straight. This worm may be 4 or 5 ctm. (2 inches) long; it inhabits chiefly the colon and cæcum. It has an alimentary canal. The

Fig. 2462.—Trichocephalus Dispar (natural size). *a*, Female; *b*, male. (Heller.)

opening of the female sexual organs is at the commencement of the thick part of the body; the male organ projects from the anus at the end of the body. The eggs are brownish, oval, and have small, bright nodules at the ends; their embryonal development probably requires months, and it is not known where this takes place; perhaps (as Leuckart thinks) there is no intermediary host for this parasite. The yearly production of eggs from one female has been estimated at three or four hundred thousand. In the alimentary canal embryos are said to develop in four or five weeks. There are usually but few of these worms present, but in one case Rudolphi found over one thousand. They occur in patients of all ages and in almost all parts of the world, but are particularly frequent in some parts of Africa. In the cæcum and colon the body and lower part of the neck lie free on the mucous membrane, while the head and anterior part of the neck cling to the membrane, and have even been supposed to be embedded in it.

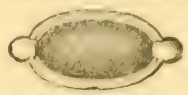
Fig. 2463.—Egg of Trichocephalus Dispar.

Heller says he has often found a hundred worms in the cæcum without appreciable change in the mucous membrane. Some authors have (probably erroneously) ascribed severe nervous symptoms to the presence of these worms; others have ascribed to them the causation of typhoid fever. As we know of no symptoms certainly induced by them, a diagnosis would be confirmed only by their passage or by finding their eggs in the stools. In regard to treatment no remedy is known, and perhaps the only likely treatment would be by forced enemata and purgatives.

Trichina spiralis in its sexually mature state is a minute nematode; the male being 1.5 mm. ($\frac{1}{16}$ inch) long, the female 3 mm. ($\frac{1}{8}$ inch); the body is thread-like and curved anteriorly; the head is pointed and unarmed; the tail of the male has a bilobed appendage, between whose branches is the cloaca containing the penis and anus. The female is larger; the genital outlet is near the anterior extremity; the ova are about $\frac{1}{2}\frac{1}{5}\frac{1}{0}$ inch long; reproduction is viviparous.

Fig. 2464. — Two Free Trichinæ in Muscular Fibre. (Heller.)

As found in the human being young trichinæ are spirally coiled worms in oval cysts; they are scarcely visible to the naked eye, being 1 mm. by 0.033 mm. ($\frac{1}{2}\frac{1}{5}$ by $\frac{1}{7}\frac{1}{6}\frac{1}{0}$ inch) in size.

Sexually mature trichinæ inhabit the intestinal canal of numerous warm-blooded animals, especially mammalia; they live four or five weeks; the second day after entering the intestines trichinæ attain maturity. The eggs of the female are developed in the uterus to filaria-like embryos, which are born without shells, after the sixth day; they number ten to fifteen thousand. They soon wander, penetrating the walls of the intestines, and entering the striped muscles generally (except those of the heart), where they develop into the trichinæ, as found, in fourteen days; after some months these acquire a calcified cyst wall; during this time they develop into adults and the sexes are recognizable. The immigration of large numbers may induce death from fever, peritonitis, etc.

Infection of man usually comes from swine, which get them from rats, who in their turn have them from man, or swine, by eating the fæces or meat. Hence microscopic examination of swine's flesh is desirable as a prophylactic measure.

Leuckart estimated that a single ounce of cat's flesh which he examined, contained 325,000 trichinæ; a like proportion in a man of average weight would give 300,000,000 or more.

It has been impossible to experimentally infect birds with them.

The symptoms of infection are anorexia, prostration, and rheumatoid pains and swelling in the limbs, but not in the joints; sometimes the limbs are contracted; in severe cases death occurs from diarrhœa and exhaustion. When trichinæ have entered the muscles no treatment avails to kill them, but if there be reason to suspect the meat soon after it has been eaten, we may give emetics, purge, and administer anthelmintics. The subsequent symptoms correspond to the period of development of the trichinæ; the ova are developed in large numbers; the embryos escape from the second to the sixth week, and work their way into the muscles; hence symptoms from this cause would come about a fortnight after ingestion of the affected meat, and continue for four or five weeks. From the rapidity with which trichinæ reach the peripheral muscles, it would seem that they might be transported by the blood, but the writer has been unable to find any exact observations confirming this view, and from their size they probably would form emboli in the capillaries. Trichinæ produce symptoms while they are in the intestines and are passing into the muscles, but after becoming encysted they may remain harmless. In the second stage there is facial œdema, the muscles are hard and painful, there is dyspnœa, and fever and emaciation are present. Where the disease ends in recovery there is usually improvement by the fourth week. During the migration of the worms the temperature of the host may rise to from 102° to 105° F. or more.

The diagnosis may be confirmed during the first weeks by finding trichinæ in the evacuations, subsequently by finding them in the muscles.

They are most apt to come from pigs that feed on offal or pasture in fields manured by sewage, etc.

Cobbold, in his "Parasites of Man and Animals," gives a long list of outbreaks of the disease (called trichiniasis or trichinosis). Many cases have been reported in this country. In 1868 the writer of this article had several cases under his observation in the New York Hospital, in which the diagnosis was confirmed by microscopic examination of portions of muscle removed from the deltoid region during life.

In these cases the disease came from eating raw or rarely cooked ham. In parts of Germany where trichiniasis occurs most frequently, the people often eat raw pork chopped fine with onions. Sausages of various kinds, not sufficiently cooked, are common sources of infection. The treatment must be almost entirely prophylactic. This would consist in exposing all parts of the meat to a high temperature; experiments seem to show that a temperature of 160° F. for a few minutes will kill trichinæ; but the boiling-point certainly will.

Filariæ are described by Leuckart as slender worms of considerable length, which either inhabit the stomach of their host, or more commonly the serous cavities or connective tissue. Some of them live in the heart. The cephalic extremity has a circular or triangular mouth surrounded by six or more small papillæ. The tail is moderately long, and in the male is spiral, and often rough on the concave side, and has two spicula projecting from it. In the female the vulva is usually in the anterior half of the body. The uterus sometimes contains eggs with hard shells (in which case they develop outside the maternal body), or free embryos which undergo metamorphosis with a change of host.

Filaria Bancrofti and *F. medinensis* have been described in the articles on Filaria Sanguinis Hominis and Dracunculus Medinensis. Other varieties of filaria encountered in man are the followning:

Filaria loa is the name given by Surgeon Guyot to a white worm, about an inch and a fourth in length (30 to 32 mm.) and as thick as a fine violin string, found under the conjunctiva of patients in the Congo and other parts of Africa. It is pointed at one end, blunt at the other. The natives say that after some "years the worm voluntarily quits the organ." Other worms of this class mentioned by Cobbold are: *Filaria lentis*, which, as the name implies, has been found in the crystalline lens. It is described as being from one-sixth to three-fourths of an inch long. Cobbold thinks the worms were probably immature wandering nematodes, belonging to some other variety.

Filaria labialis is the name given to a worm found in a pustule on the upper lip in a patient at Naples; it was a male, cylindrical in shape, and one and a fourth inch long; the mouth was armed with four papillæ. Leidy describes a similar worm.

Filaria hominis oris, described by Dr. Leidy, also from a single specimen, was five inches long, a white opaque filaria, mouth round, the posterior end obtuse and having a minute hooklet. Cobbold thinks this also was an immature worm.

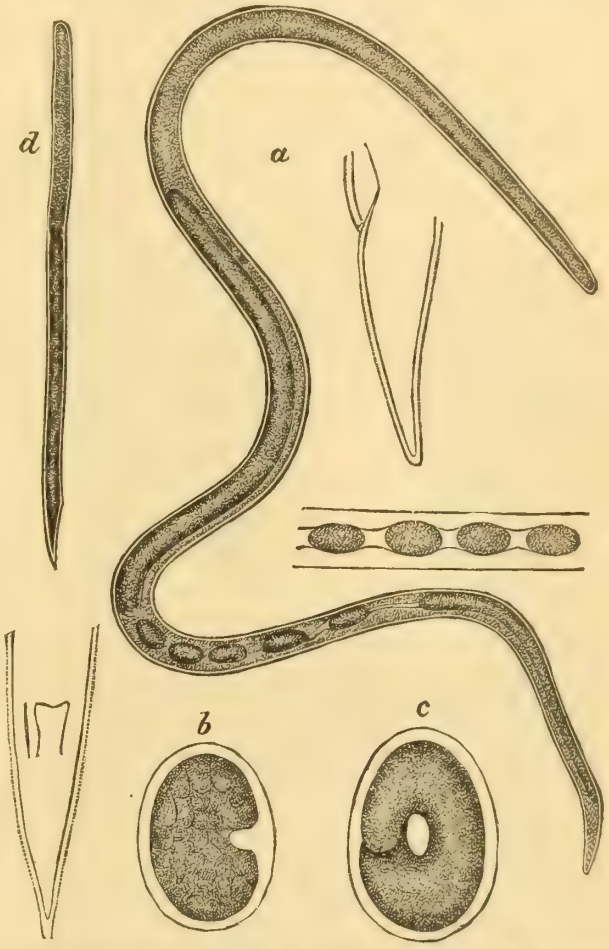

FIG. 2465.—Leptodera Intestinalis. *a*, Adult female and separate figure showing a portion of the body with ova *in situ*. The two outlined figures represent profile and front views of the tail. *b*, *c*, Eggs with imperfectly-formed embryos; *d*, larva. Highly magnified. (After Bavay, in Cobbold's "Parasites.")

Filaria trachealis is also considered by Cobbold as a "juvenile stage of growth of some species of round worm." A number of these worms, each about one-fiftieth of an inch in length, were found in the larynx and trachea of a person who died from a disease affecting the lower extremities. Leuckhart quotes a case where nematodes fifteen to twenty-six millimetres long, were found in the lungs of a boy; these were described as strongylus longevaginatus by Diesing.

Filaria bronchialis (*hamularia lymphatica* of Treutler) is a filamentary worm about twenty-seven millimetres long, curved at both ends, in color dark brown with white spots, the posterior end being semi-transparent. At the anterior extremity it has two hooks. Specimens of

this worm were found in the enlarged bronchial glands of a phthisical patient by Treutler.

Lingula Metasoma is the name given by Cobbold to certains worms found post mortem by P. Manson in a Chinaman, in 1881. They "were found in the loose areolar tissue behind the kidneys, and in the subperitoneal areolar tissue in the flanks and iliac fossæ." There were twelve in all, white, twelve to fourteen inches long, one-eighth of an inch wide, and one-sixtieth thick; ends rounded, one end lipped, the other with a short longitudinal slit. This seems to be the only reported case. This patient had filaria sanguinis, and died after an operation for lymph scrotum. It is not known whether this worm has any pathological importance.

Leptodera (*anguillula*) *stercoralis* is the name given to a small nematode ($\frac{1}{28}$ of an inch long, $\frac{1}{2\,8\,8}$ thick) which was seen in many cases of Cochin-China diarrhœa. When present it was found in immense numbers, computed at hundreds of thousands. They were found in all parts of the intestinal canal, and even in communicating gland-ducts. They develop in about five days.

A somewhat larger species, found under similar circumstances, is *leptodera intestinalis*.

Chas. E. Hackley.

NENNDORF is a sulphur spa in Hesse-Nassau, lying in a pleasant valley at an elevation of some 200 feet only above the level of the sea. The climate is rather changeable, and visitors are obliged to observe some caution as regards their dress. There are four springs, the waters of which are employed for therapeutical purposes. The following are the analyses of two of these, the amounts of saline constituents being expressed in grammes per litre:

	Trinkquelle.	Badequelle.
Calcium sulphide	0.068	0.016
Sodium sulphate	0.564	0.247
Potassium sulphate	0.042	0.016
Calcium sulphate	1.007	0.677
Calcium carbonate	0.419	0.439
Magnesium chloride	0.229	0.063
Magnesium sulphate	0.287	0.224
Silicic acid	0.020	0.128
Total solids	2.636	1.810

The gases are sulphuretted hydrogen, nitrogen, and carbonic acid.

These waters are given internally, and are employed externally in all the common ways, by means of mud-baths, water-baths, vapor-baths, inhalations, wet compresses, etc. When used for bathing the strength is increased by the addition of a brine containing iodine and bromine in small proportions. When taken internally the water is frequently "cut" with goat's milk or whey.

The therapeutical indications for Nenndorf are the same as those for the sulphur-waters in general, viz., gout, rheumatism, syphilis, mercurialism, chronic respiratory catarrhs, scrofulous affections, obstinate skin-diseases, neuralgia, etc. The season lasts from the middle of May to the middle of September, and the duration of a course of treatment is usually from three to four weeks. The spa is visited by from fifteen hundred to two thousand patients annually. The accommodations are said to be good. *T. L. S.*

NÉRIS is a thermal station in the Département de l'Allier, France, lying in a small valley at an elevation of about 1,100 feet above the sea. The establishment is under government control, and the accommodations and appointments are said to be excellent.

Néris is chiefly frequented by sufferers from various neuroses, rheumatism, some forms of peripheral paralysis, neuralgia, diseases of women, certain dermatoses, and stiff and swollen joints resulting from traumatism. The season extends from the middle of May to the middle of September. The climate is on the whole pleasant, though in the middle of the day the heat is sometimes oppressive.

There are six springs, varying but little in their mineral constituents. The following is the composition of one of the springs, the Puits de César, after the analysis of M. Jules Lefort. One litre contains of

	Grammes.
Sodium bicarbonate	0.1169
Calcium bicarbonate	0.1455
Potassium bicarbonate	0.0129
Magnesium bicarbonate	0.0057
Ferrous bicarbonate	0.0042
Manganous bicarbonate	trace
Sodium sulphate	0.2586
Sodium chloride	0.1788
Sodium iodide and fluoride	traces
Silicic acid	0.1121
Organic matter	trace
Total solids	1.2057

The gases are nitrogen and carbonic acid. The temperature of the different springs ranges from 115.5° to 129 F. The waters are seldom taken internally, their principal employment being in the form of baths.

T. L. S.

NERVES, GENERAL PHYSIOLOGY OF. Elementary Laws.—1. *A nerve is irritable at all points in its course*, in the sense that the normal and necessary effect of the activity of the nerve in producing, for example, a muscular contraction or a sensation, may be obtained by stimulating it at any point in its course.

2. *Anatomical continuity between the point of stimulation and the terminal organ is essential to the stimulation of the latter;* if a nerve be divided and the ends placed in accurate apposition no stimulant action will pass the point of section, nor will it pass a place which has been compressed, as by a string tied tightly around it.

3. *No immediate destructive effect is produced by the section of a nerve except at the place of section, and the irritability and conductivity at other points are for a time essentially unimpaired.*

4. *There is no diffusion of stimulation from one nerve-fibre to an adjacent one in the same funiculus*, but a stimulus applied to any nerve-fibre is restricted to that and its terminal branches, except so far as it may be distributed on reaching a ganglionic centre.

We may conclude from these facts that that which passes along a nerve to stimulate its terminal organ is not a substance, but a molecular disturbance which is propagated from point to point. We shall call this the *nervous impulse*.

We have to determine the properties of this molecular disturbance.

Neither chemical, thermal, nor optical phenomena have been directly observed in connection with the activity of nerve-fibres. While, from general considerations and somewhat distant analogies, we may presume that some chemical changes are effected in the passage of a nervous impulse, and that waste products are formed; and while, also, it is not improbable that heat is developed, the only features of the functional activity of nerve-fibres which can be directly observed are the effects produced in the terminal organs, such as a muscular contraction or a sensation, and certain electrical changes. We proceed, then, to the description of these electrical phenomena.

Electrical Phenomena of Nerves.—*Currents of Rest.*—If a piece of nerve be removed from the body, its cut ends will be found to be negative to its longitudinal surfaces, so that if the longitudinal surface and the end be connected by a wire terminating in non-polarizable electrodes, a current will pass through the wire in the direction from the longitudinal surface to the end. The maximum current will be obtained when one electrode is placed on the cut surface, and the other about the middle of the longitudinal surface of an exsected piece of nerve, and weaker currents will pass between points on the longitudinal surface unequally distant from the middle. These currents are called "currents of rest."

The electromotive force was found by Du Bois-Reymond in frogs' nerves as high as .022 Dan., and in those of the rabbit as high as .026 Dan.

Du Bois-Reymond ("Ges. Abhandl.," Bd. ii., S. 196, or *Arch. f. Anat. u. Physiol.*, 1867, S. 267) noticed that a feeble current was to be obtained between the two cut ends of the sciatic nerve of the frog. Fredericq (*Arch. f.*

Anat. u. Physiol., 1880, S. 68, Anm.) observed the same thing in the nerves of warm-blooded animals. Du Bois-Reymond again ("Sitzungsb. d. Akad. d. Wiss. Z.," Berlin, 1884, Bd. i., S. 230 ff.) found that a segment of one of the nerves to the electric organ of the torpedo was always more negative on its peripheral than on its proximal end, so as to furnish an upward current in the nerve. In 1885 Mendelssohn (*Arch. f. Anat. u. Physiol.*, Physiol. Abth., 1885, S. 381 ff.) made this *axial current* the subject of a special investigation which yielded the following results:

The axial current was ascending in the branches of the sciatic of the rabbit supplying the muscles of the thigh, and in seventy-six per cent. of the anterior roots of the spinal nerves, as examined in the frog and rabbit; and descending in the posterior roots of the frog and rabbit, and in the optic and olfactory nerves of the pickerel and the carp. In the mixed nerves (sciatic of rabbit and frog) it was in different cases up and down. So that in all nerves held to consist of fibres running in one direction only, with the exception of twenty-four per cent. of anterior roots in which the current was descending, *the axial current was in an inverse direction to that of the functional activity.* The twenty-four per cent. of anterior roots in which the current was descending, which included both those of the frog and the rabbit, form so small an exception that their explanation in the future seems not unlikely; though that of recurrent sensibility offered by Mendelssohn does not seem to meet the case, since the recurrent afferent fibres in these roots, of course, act in the same direction as the efferent.

The currents of rest increase at first with the temperature, and then decline. The temperature at which the maximum current occurs was found by Steiner (1876) to vary between 14° C. and 25° C.

The current which is yielded by a cut end gradually diminishes, but it may be obtained again in nearly its original strength from a new section of the same nerve. The power, however, of affording active sections gradually dies out in the nerve removed from the body, although it persists after the loss of power of stimulating the muscle.

Currents of Action.—The current of rest is diminished when the nerve is tetanized, that is, subjected to a series of rapidly repeated stimuli, electrical, mechanical, chemical, or reflex. This diminution is called the *negative variation.* It is not due to increased resistance in a functionally active nerve, but to a diminution in the difference of potential at the two ends of the conductor.

When a momentary stimulus, as a single induction shock, is applied to one end of a nerve, a wave of lowered potential passes along the nerve. If a wire be made to connect two points of a nerve through which such a wave is passing, currents will flow through it first in one direction and then in the other, as the crest of the wave passes first one and then the other end of the wire. In order to show this, it is necessary that the velocity of the impulses be diminished by cooling the nerve. These are called "currents of action."

The velocity of this wave of lowered potential has been determined for frog's nerves at from twenty-eight to thirty metres (90 to 98 feet) a second, while the wave itself has a linear extent of about .02 metre ($\frac{1}{8}$ inch).

When a nerve is tetanized, a succession of such waves passes over the nerve. If the cut end is connected with a point on the longitudinal surface through a galvanometer, the needle during tetanization swings back toward zero. The needle moves too slowly to follow the changes of potential, at the point of application of the wire to the longitudinal surface, caused by the passage of the individual waves, but takes a position corresponding to the *average* difference of potential. The needle does not swing back to zero; which shows that the *average* condition of the point on the longitudinal surface is, during tetanization, still positive to the cut end; but it does not show that the most negative phase of this point, as the wave passes, is positive to the cut end. As to this no certain statement can at present be made.

Heller ("Ueber positive Nachschwankung des Nervenstromes nach electrischer Reizung," "Sitzungsb. d. Akad. d. Wiss.," Wien, Februar, 1884) finds a positive current following the negative after the tetanization of a nerve. For this the nerve must be fresh. This positive variation increases to a limit with the strength of the stimulus, and with the duration of the stimulus to a maximum, and if the duration is still further increased the positive variation diminishes to zero. But if the nerve, tetanized so long that a positive variation does not follow the cessation of the stimulus, is allowed to rest for a while, the positive variation may be again obtained by stimulation. In a series of short tetanizations, the positive variations obtained successively diminish from first to last.

Du Bois-Reymond ("Lebende Zitterrochen in Berlin," "Sitzungsb. d. Kgl. Preuss. Akad. d. Wiss.," 13 März, 1884, S. 233, and reprinted *Arch. f. Anat. u. Physiol.*; Physiol. Abth., 1885, S. 138) twice saw this positive variation following the negative in the electrical nerves of the torpedo, and in the same nerves he and Christiani observed a positive variation preceding and ushering in the negative.

Pflüger (1859) was unable to obtain secondary tetanus, due to the oscillations of the negative variation with a rheoscopic limb, from a nerve as it may be obtained from a muscle. It is true that with strong interrupted currents we may get secondary tetanic contractions, but these are due to the variations in electrotonus and not to those of the negative variation (paradoxical contraction of Du Bois-Reymond). Hering has, however, more recently obtained this secondary tetanus dependent on the negative variation (Hering: "Ueber Nervenreizung durch den Nervenstrom," "Sitzungsb. d. Akad. d. Wiss.," Wien, März, 1882, lxxxv., S. 237).

The Velocity of the Nervous Impulse.—If the nerve supplying a muscle be excited by a momentary stimulus, a certain time will elapse before the contraction of the muscle. If it be stimulated at another point nearer the muscle, this delay will be less. The difference is plainly the time occupied in traversing the nerve between the two points. In this way the velocity of the nervous impulse in the motor nerves of the frog has been determined as about twenty-eight metres a second, and in those of man as about thirty-three.

The determination of the velocity in the sensory nerves is less reliable. The method consists in noting the difference in the times required for signalling the perception of a stimulus applied to two points at different distances from the brain, as at the hip and toe. But the results are very discordant, and are of little value. They run from twenty-five to two hundred and twenty-five metres a second.

The velocity of the nervous impulse in the frog and in man varies with the temperature, and with the intensity of the stimulus (?) and in different nerves and in different portions of the same nerve, and is influenced by the passage of a constant electric current through the nerve.

Influence of the Temperature. A lowered temperature diminishes the velocity; even accidental changes in the temperature of the room are not without effect, and artificial cooling produces much greater diminution. In human motor nerves Helmholtz and Bate (1870) found the velocity to vary with the temperature between thirty and nearly ninety metres (98 and 295 feet) a second.

Influence of the Strength of Stimulus. On this point observations are not concordant, some evidence going to show that a stronger impulse travels faster than a weaker one. But the question must be considered as still unsettled.

Influence of the Location in the Nerve and of the Space already Traversed.—There is no evidence that the velocity varies with the space traversed, nor that any difference in the wave itself, with the possible exception of increased or diminished intensity, modifies its velocity; but any change in the velocity depends on the character and condition of the nerve traversed.

With respect to variations in the specific velocities of different portions of the nerves, although the testimony is not altogether unanimous, the weight of evidence

seems to be in favor of a difference in the upper and lower portions of motor nerve-fibres in men and frogs, the specific velocity of the upper portion being given as only one half that of the lower segment. Thus Place (1870) determined the velocity in the region of the upper arm of man as from 12 to 23.9 metres, while in the forearm it was from 52 to 62 metres.

Different nerves probably differ somewhat in the velocity of transit of the nervous impulse; thus, in the pharyngeal branches of the vagus, Chauveau found it only 8.2 metres.

Influence of the Passage of the Constant Electric Current.—Von Bezold (1859–61) found that the passage of the electric current diminished the velocity in the extrapolar as well as in the intrapolar regions, and stated that this was true for both catelectrotonus and anelectrotonus. Rutherford (1867) found that, while these results were true for strong currents, or after long application, for weaker currents applied for a short time the velocity was diminished only by anelectrotonus, and was increased by catelectrotonus. Wundt (1871) came to the same result.

Relation between the Nervous Impulse and the Wave of Lowered Potential.—The velocity of the wave of lowered potential in frogs nerves has been determined as equal to that of the nervous impulse, so that it keeps pace with it, whether the nervous impulse, or that molecular disturbance which serves as a stimulus to the terminal organ, absolutely coincides, as to the portion of the nerve where it occurs, with the electrical disturbance or not. The velocity of the one is affected in the same way by the same agents as the velocity of the other; and the intensity of the nervous impulse, as measured by its effect on the muscle, varies with that of the electric disturbance.

The following general statement may then be made: *The wave of lowered potential shows the presence, has the velocity, and measures the intensity of a nervous impulse.* This law is supported in all its points by a large amount of evidence brought forward by various observers, and has encountered, as yet, no well-sustained controverting facts.

The Conductivity of Nerves in both Directions.—There is no evident reason why a nerve-fibre should be different in one direction from what it is in the other. The efferent and afferent character of these fibres is sufficiently determined by their terminal connections. There are no known microscopical differences in the two directions. There do seem, however, to be physical differences. In the first place the secondary electromotor effects do not seem to be independent of the direction of the polarizing current, as up or down the nerve, and in the second place, we have the axial currents described above. The attempts to prove the similarity of the nerves acting in each direction, by uniting the peripheral end of a divided motor nerve, as the hypoglossal, with the central end of a divided sensory nerve, as the lingual, have proved unsatisfactory.

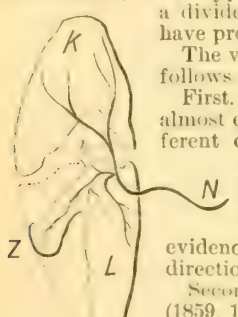

Fig. 2466.—Gracilis of the Frog. *K*, the upper segment; *L*, the lower segment; *N*, the nerve; *k*, the branch going to upper segment.

The valid evidence is twofold, and as follows:

First. If a nerve consisting entirely or almost entirely of fibres of one kind, afferent or efferent, is stimulated in its course, the negative variation is produced equally at each end; therefore the nervous impulse, of which this electrical change is an evidence, travels equally well in either direction.

Second. It has been shown by Kühne (1859, 1886) that if some of the terminal branches of a motor nerve-fibre of a frog be stimulated at their extremities, all of the muscle-fibres supplied by the other branches of the same nerve-fibre will be thrown into contraction.

Thus in the figure (Kühne, *Zeitschr. f. Biologie*, 1886), when *Z* is stimulated, *K* is thrown into contraction. In this case the nervous impulse travels up the motor fibrils in *Z* to the junction, and in this part of its course it moves in a direction the reverse of normal; it then passes down through *k*. The branching of the nerve-fibres above the point of junction has been shown anatomically by Mays.

The same form of experiment has been employed by Babuchin (1877) on the large branching nerves of the electrical organ of Malopterurus, with the same result.

This proof is, of course, applicable to efferent nerves alone.

Electrotonus.—When a constant current is passed through a certain length of nerve, four effects are produced in the vicinity of the electrodes. There is a variation (1) of potential, (2) of the irritability, (3) in the velocity of nervous impulses, and (4) in the behavior of currents of action in that region. To these effects the name of electrotonus is given. The changes effected in the region of the cathode are called *catelectrotonus*, and those in the neighborhood of the anode *anelectrotonus*.

Electrotonic Variation of Potential.—When a constant current is passed through a portion of a nerve, and a conductor is made to connect two points of the nerve in the same extrapolar region, a current passes through the conductor in such direction that, if the circuit is supposed completed by the piece of nerve lying between the extremities of the conductor, the current in the nerve would be in the same direction as the polarizing current. These electrotonic currents are independent of the currents of rest, and are simply added to them or subtracted from them, according as they run in the same or in opposite directions.

In the figure, *B A C* is the constant or polarizing current; *K G L* and *M G′ P* the electrotonic or derived cur-

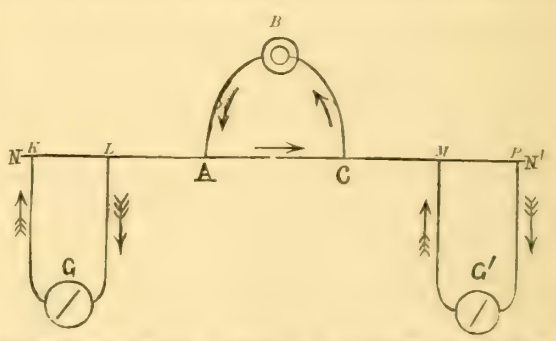

Fig. 2467.—*N N′*, Nerve: *B*, battery: *A*, anode: *C*, cathode: *G G′*, galvanometers.

rents. The portion of the nerve between *A* and *C* is called the intrapolar region, and that beyond *A* or *C* on either side the extrapolar region. It is evident that in *G* the current of rest and the electrotonic current will be in the same direction, and so will reinforce one another, while in *G′* they will counteract one another.

Electrotonic currents do not flow in dead nerves, nor will they be found beyond a section even if the ends be placed in close apposition, nor beyond a ligature tight enough to interrupt the functional activity of the nerve.

The strength of the electrotonic current increases: 1. Without limit with the strength of the polarizing current. 2. With the length of the intrapolar region, *A C* of the above figure. Strictly transverse currents produce no electrotonus. 3. With the approximation of the nearer electrode (*L* or *M*) of the electrotonic current to the neighboring electrode (*A* or *C*) of the polarizing current. 4. With the interval (*K L* or *M P*) between the electrodes of the electrotonic current, allowance being made for the increased resistance. 5. The electrotonus beyond the anode is greater than that beyond the cathode.

The Development and Disappearance of Electrotonic Currents.—Both catelectrotonus and anelectrotonus are developed immediately on the closing of the polarizing current. The catelectrotonus comes quickly to a maximum and then diminishes; the anelectrotonus increases more slowly, but reaches a greater intensity than the catelectrotonus.

It takes a little time for the galvanometer needle to

come to position, and, therefore, the curves between t and t' (Fig. 2468) are conjectural.

When the polarizing current ceases, the catelectrotonic current persists for a short time, while the anelectrotonic

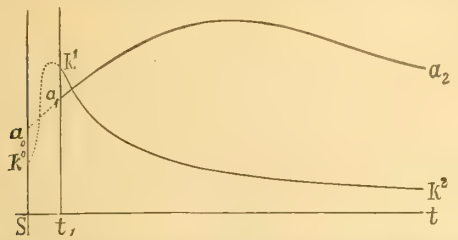

FIG. 2468.—Abscissas measured from S represent the time after the closing of the polarizing circuit; a, curve of intensity of anelectrotonic current; k, curve of intensity of catelectrotonic current.

current is reversed; the latter current is the stronger. In the intrapolar region a reversed current follows the cessation of the polarizing current.

Electrotonic Variation of Irritability.—When the polarizing current is passing, the irritability in the neighborhood of the cathode is increased, and that in the neighborhood of the anode is diminished. This applies to both the extrapolar and intrapolar regions, and to stimuli of all kinds. The increase and decrease of irritability are represented by the ordinates of the following curve:

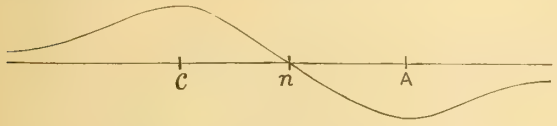

FIG. 2469.—C, Cathode; A, anode; n, neutral point.

The maxima and minima of irritability lie at the cathode and anode. A current of such strength can be found that the point n, at which the irritability is unchanged, will lie half-way between C and A; a stronger current will carry it toward C, while with one of less strength it will lie nearer to A.

The electrotonic modification of irritability at any point of the nerve increases with the strength of the polarizing current to a maximum; a further increase of the current increases the electrotonus only at a more distant point.

Electrotonus also increases with the length of the intrapolar region, the strength of the current being kept the same.

The phenomena, as tested by the currents of action, are the same whether the polarizing current is ascending or descending.

The catelectrotonus develops immediately on closing the polarizing circuit, increases then quickly a little, and then slowly diminishes.

The anelectrotonus develops more slowly to a maximum, and then diminishes. When the current is broken, the anelectrotonic region assumes an irritability higher than that of the unaffected nerve, while the catelectrotonic region presents an evanescent phase of lower irritability than normal, lasting for only a few seconds, and which is succeeded by higher irritability than normal, lasting for some time, that is, from half a minute to fifteen minutes. These after-effects are the more persistent the stronger the polarizing current has been, except that the brief lowering of irritability in the cathodal region is more brief the stronger the current.

Electrotonic Variation of the Velocity of the Nervous Impulse.—This has been already discussed above.

Electrotonic Variation of the Currents of Action, and presumably of the Nervous Impulse.—If while the electrotonic currents are observed the nerve is tetanized, the currents are seen to diminish. This must be due to a change of resistance or of potential. A variation of resistance seems to be disproved, and the change of potential would be explained by supposing that the wave of lowered potential was more intense at P (Fig. 2467) than at M, and more at L than at K, or that the wave of lowered potential which started at N', diminished from N to C, that is, in going from a point of less to one of greater catelectrotonus, and in going from A to N, or from a point of greater to one of less anelectrotonus. If, on the other hand, the stimulation was from the other end, we should have the same effects on the galvanometers, so that we should be brought to conclude that the wave of negative variation grew in intensity from N to A, and from C to N'. Since, then, this negativity is greatest at A and least at C, the current through the circuit B should be increased by stimulation, and this is shown to be the fact. These changes of potential, due to nervous stimulation, may be regarded as indicating similar changes in the nervous impulse as it travels from N to N', or from N' to N.

STIMULATION.—The various agents which evoke the nervous impulse are called stimuli, and the application of such stimuli, so as to start a nervous impulse, is known as stimulation.

Besides the natural stimuli coming from the end-organs of sensory nerves or the central ganglia of efferent nerves, there are various stimuli which can be applied to the nerves in their course for the purposes of experiment; such are mechanical shock, as tapping, cutting, or crushing, and various chemical substances, which act either chemically or by the withdrawal of water, as neutral alkaline salts, free alkalies, free acids, salts of the heavy metals, sugar, glycerine, and other substances; the withdrawal of water seems to be a stimulus, while thermal changes, which are not immediately destructive, are not yet conclusively proved to act in this way, although they do affect the irritability. The electric current, however, is, beyond all other stimuli, adapted to the purposes of experiment, from the ease with which it can be applied, the fact that it produces less permanent alteration of the nerve to which it is applied than mechanical or chemical stimuli, and the accuracy with which its area of application can be restricted and defined, and with which the strength of the stimulus can be graded and measured; while the fact that electrical currents attend the nervous impulse gives the investigation of electrical stimulation additional importance, as bearing on the fundamental mechanism of nervous action.

Electrical Stimulation.—When a constant current is passed through a motor nerve, a contraction may be made at the beginning or end of the passage of such current, or at both the beginning and end, but no contraction is maintained during the passage of the current in ordinary circumstances. (See below on Tetanus from Constant Currents.)

The stimulation depends on the strength and concentration of the current, and the extent and suddenness of its variation. The stimulation, when the current is made or is suddenly increased, occurs at the cathode; when the current is broken or suddenly diminished, at the anode; in other words, the stimulation is due to a sudden rise in catelectrotonus or to a sudden fall in anelectrotonus; in either case it is a passing from a state of lower to one of higher irritability. It is in accord with this view of the dependence of stimulation by electric currents on their electrotonic effects, that, with equal currents, the stimulation increases with the length of nerve traversed, at least within certain limits, and that no stimulation is produced by strictly transverse currents.

THE LAW OF CONTRACTION.—It is found that the production of a contraction depends, *cæteris paribus*, on the strength of the current, on its direction, and on whether the current is made or broken. The usual order of events in such experiments is exhibited in the following table:

Current.	Ascending.		Descending.	
	Make.	Break.	Make.	Break.
Weak	C*	O	C	O
Moderate	C	C	C	C
Strong	O	C	C	O

* C indicates the presence, O the absence of contraction.

To this tabular statement the name law of contraction has been given. The results may be explained as follows: With moderate currents the electrotonic resistance to the passage of the nervous impulse is not sufficient to obstruct the passage of the impulses arising from the making of the ascending current or the breaking of the descending current; consequently we have a contraction in all four cases. When, however, the strength of the current is increased, the making impulse starting from the cathode must traverse a strongly anelectrotonic region on its way to the muscle, and becomes here lost. Again, the breaking impulse of a strong descending current must pass through a region where the conductivity is for a time strongly diminished.

With the weak currents it is necessary to assume that the making stimulus is, in itself, stronger than the breaking stimulus. Moreover, with these weak stimuli the fact that the nerve is more irritable near its cut end (see below) contributes to the result. With ascending currents these two factors work in the same direction, but in descending currents they are in antagonism, and we have sometimes a reversal of the effects exhibited in the table for weak descending currents. With a current of a certain strength we may obtain a slight tetanus, continuing while the current lasts. For this, if the proximal portion of the nerve is stimulated, the descending current is most effective; while for a peripheral point of stimulation the ascending current is the stronger. Frogs which have been kept in the cold seem to be especially liable to exhibit this tetanus.

If a strong current is passed for a long time through a long stretch of nerve, and then the current is broken, a tetanus ensues lasting for a considerable period. This is called Ritter's opening tetanus. It starts from the anode. The reclosing of the original current inhibits, and a reversal of that current increases, the tetanus (Volta's alternative).

The Stimulation as Dependent on the Duration of the Current.—Since anelectrotonus develops more gradually than catelectrotonus, we should expect to find with quite short currents a cathodal making stimulation, while the anodal breaking stimulation was absent, and Fick (1866) has shown that with an induced current the intensity of the contraction was increased when the cathode, and not when the anode, was applied to the cathodal region of a polarizing current. Moreover, Lamansky (1868) found that the delay in the muscular contraction varied with the position of the cathode, and not with that of the anode, of an induced current. These results, however, were obtained with rather weak induction currents. With stronger ones we might have anodal breaking stimulation, because, though the time were too brief to allow the development of the full measure of anelectrotonus, it might still be long enough for the development of sufficient to originate a nervous impulse by its departure.

König (1870) found that with very short descending constant currents, yielding maximal making, but no breaking, contractions, no contraction ensued when the duration was less than .0015 second, and that the effect increased as the duration was lengthened up to about .018 second. Moreover, cold increased the lower limit of duration, so that at 0° C. a duration of almost .02 second was necessary for the least effect. Gruenhagen ("Ueber das Verhältniss zwischen Reizdauer, Reizgrösse und latente Reizperiode," *Arch. f. d. Gesammt. Physiol.*, Bd. 33, 1884) found with weak currents the minimum necessary duration .0018 to .0023, while with stronger currents it diminished to .0009, .00035, and .00057. But he found no such difference as Helmholtz and König, between the duration of the shortest current giving maximum effect and the shortest current giving any effect whatever. The ratio in the results of Helmholtz and König was 1 : 8.3-8.8, while Gruenhagen finds it to be only 1 : 1.3 2, or rarely as far as 1 : 2.5.

Dying nerves (Neumann, 1864) are comparatively unirritable to currents of very short duration, and the same condition seems to obtain in certain pathological states.

Unipolar Stimulation.—We have seen that electrical stimulation depends on the changes in currents of electricity through nerves. We have heretofore supposed these nerves to form part of a closed circuit. It is found, however, that stimulation is sometimes produced when the nerve forms part of the *open* secondary circuit of an induction coil. This is called "unipolar stimulation," and is due to the momentary movement of electricity toward one end or the other of the secondary circuit and the parts connected with them. This movement is most free, and the stimulation greatest when the two ends of the circuit are large plates near to one another, such as the coatings of a Leyden jar; but the connection of the nerve with the earth has considerable effect, and so, too, with a single conductor. The approach of a large conductor, by its inductive action, may intensify the unipolar action; so the approach of a finger to a previously inactive nerve connected with the open circuit of the secondary coil of an induction machine in operation, may cause the muscle to contract.

A circuit closed by a poor conductor may also yield unipolar effects. Thus, when the circuit is closed by a long piece of fine nerve, and the nerve is ligatured between the electrodes and the muscle, and some connection with the earth is made below the ligature, contractions may ensue which are due to unipolar stimulation of the nerve between the ligature and the muscle. It is not necessary, however, that the muscle or nerve be connected with the earth; connection with a large conductor is sufficient, and hence the galvanometer circuit in experiments on negative variation favors the occurrence of unipolar stimulation.

Unipolar stimulation may be avoided by using currents from the battery instead of induced currents; by avoiding the breaking induced current; by using weak currents; by connecting the stimulating electrode, which is directly connected with the secondary coil, with the ground; and, when it is feared for an open circuit, by using a short circuiting key instead of a simple make-and-break key; and in closed circuits, by making the distance between the stimulating electrodes as short as possible.

Maximal and Supermaximal Stimulation.—The muscle-contraction increases with the strength of the (electric) stimulus to a maximum. If, when single induction shocks are employed, the strength of the stimulus be still further increased, there is a second increase in the extent of the muscular contractions, which reach speedily a second maximum. The existence of these two maxima is observed in the currents of action, so that the phenomenon concerns the nerve, and not simply the muscle. It is explained by the superposition of the anodal opening on the cathodal closing stimulation.

With increasing ascending brief currents, Fick and others found that a point was reached in which the action failed, that is, there was an "interval," which Fick explained by the obstruction of the nervous impulse from cathodal stimulation by the anelectrotonus between it and the muscle. But as Tiegel (1875) finds the same interval with descending currents, this explanation is inapplicable.

Modifications of Irritability.—The nervous element, when stimulated, receives a certain amount of kinetic energy and passes a certain amount of energy of the same kind to the next element as a stimulus. In this way the nervous impulse traverses the nerve. The phenomena of exhaustion, the analogy of muscle-tissue and of living tissues in general, the existence of electrical currents in which some energy must be dissipated, lead us to conclude with some confidence that when a nervous element is stimulated there is a conversion of potential into kinetic energy, and that a portion of the kinetic energy thus generated is passed on as a stimulus to the next nervous element. We have then two important, though unknown, relations existing here: (1) The ratio of the kinetic energy which an element receives as stimulus, to the total kinetic energy which is under this stimulus evolved from its potential energy; and (2) the ratio of this kinetic energy, thus evolved, to that passed on as stimulus to the next element. But it is evident that, so far as the immediate effect in stimulating the terminal organ is concerned, the important relation is

neither of these, but the product of the two—that is, the ratio of the stimulus which the element receives to that which it furnishes its neighbor next down the line. The question which we shall have later to consider is, whether this ratio is a ratio of equality or not. But if this ratio were in all cases unity, it would still be possible that the ratio of the stimulus-kinetic energy to the total kinetic energy evolved might be different in different cases; and while this would not affect the action of the particular nervous impulse on the terminal organ, it might affect its successor, or, in other words, have peculiar relations to the phenomena of exhaustion.

The relation of the kinetic energy which a nerve-element receives from its neighbor on one side, to that which it passes on to its neighbor on the other, is called the *internal irritability*. The relation of the external stimulus to the kinetic energy passed from the stimulated element to the next would be, logically, the thing to be called the *external irritability*; but this name is generally used to denote the relation of the external stimulus to the result of such stimulation, muscular contraction, reflex action, currents of action, etc.; although this relation is evidently a function of both the internal irritability and of the external irritability in the stricter sense given above.

One might easily conceive how the nerve might be rendered more irritable to some one or another form of external stimulus, through some change in itself or its immediate surroundings, without a corresponding change in its internal irritability, or its irritability to other forms of stimulus than that one; but it is difficult to imagine a nervous element more irritable than normal to *all* forms of stimulus coming from outside, and yet, with respect to the stimulus coming from its neighbor, preserving its usual irritability unchanged. It would be satisfactory, if we could discuss the conditions of the irritability of the nervous element, whether the stimulus was internal or external, and then those conditions which made the various external applications of force more or less effective as furnishing a real stimulus. In the present state of knowledge, however, this more analytic method is impossible, and we must consider external and internal irritability and their modifications separately.

External Irritability.—External irritability is affected by temperature, by the humidity of the nerve, by pressure, by poisons, and by the vital condition of the part. In addition to these, we have the electrotonic changes of irritability, which have, however, been already sufficiently discussed.

In determining the variations of the external irritability of the nerve under varying influences, a portion or the whole of the nerve is subjected to those influences, and in most cases the minimum stimulus capable of producing a contraction is determined. This method gives the variations of irritability for small stimuli, but the results cannot be applied directly to stimuli of all kinds, for it is certainly conceivable that the irritability for larger stimuli might not keep pace with that for small stimuli.

Temperature.—When the temperature of the frog's nerve is raised from that of the room to a higher temperature, under 50° C., the irritability is at first greater, and then becomes less, than before. The higher the temperature the shorter the period of increased irritability, and the more profound the loss of irritability in the second stage. The proximal portions of the nerve are more susceptible to a rise of temperature than the distal. (Efron: "Beiträge zur allgemeinen Nervenphysiologie," *Pflüger's Archiv*, Bd. 36, S. 467 ff., 1885.) The irritability lowered or lost through increased temperature, may be wholly or partially restored again by lowering the temperature. When the temperature of the fresh nerve is suddenly diminished from twenty degrees to less than ten degrees, there is a brief increase of irritability, at least in the peripheral portions of the nerve, but this is quickly followed by a lowering or absolute loss of irritability; the original state is regained by warming again to the temperature of the room.

Humidity.—The drying of a nerve increases its irritability, but destroys it if it is carried beyond a certain point. A nerve which has lost its irritability by drying may regain it on being moistened. Soaking a nerve in water or very dilute saline solutions diminishes its irritability.

Chemical Agents.—Numerous chemical agents affect the irritability of nerves. Usually the irritability is increased and then diminished, and the phase of increase is longer with weak solutions, and may be exceedingly short with concentrated ones. Such diphasic action has been shown in the case of ethyl alcohol, 1 or 2 per cent.; methyl alcohol, 1 or 2 per cent.; propyl alcohol, 1 per cent.; butyl alcohol, 1 per cent.; amyl alcohol, 0.2 per cent. (amyl alcohol in stronger solutions than one per cent. abolishes irritability apparently without a preliminary phase of increase); glycerin, 12 per cent.; solution of sodium chloride, 2.5 per cent., and chloroform vapor. Cocaine lowers the irritability of both motor and sensory nerves.

Pressure and Stretching.—When the nerve is subjected to slight pressure the irritability is increased; when the pressure is greater it is diminished, and the proximal portions of the nerve are more susceptible to this treatment than the distal. Continued pressure on a mixed nerve is said to paralyze the motor sooner than the sensory fibres.

Slight extension increases the irritability, but greater extension diminishes and may abolish it. The sensory fibres of the sciatic nerve are said to be more easily paralyzed by stretching than are the motor.

Vital Conditions.—Under vital conditions will be considered: 1. The differences of irritability in different nerves and at different points of the same nerve. 2. The influence of a cut section. 3. The influence of separation from trophic nervous centres. 4. The influence of previous stimulation.

1. *Differences of Irritability in Different Nerves and at Different Points of the Same Nerve.*—That different nerves or the nerve-fibres of a single trunk vary in their irritability is altogether probable, but it is not proved, unless we accept the so-called Ritter's phenomenon as decisive. Ritter found that when the sciatic nerve of the frog was stimulated with a weak current the foot was flexed (dorsally), and with a strong current the extensor muscles (gastrocnemius) obtained the upper hand. The fact is easily verified.

But there is some reason to believe that this depends on a difference of irritability in the muscles rather than in the nerves, as similar results may be obtained in stimulating the extremities of curarized frogs.

The variation of the irritability of nerves along their course has been the subject of considerable investigation, and the general outcome, as regards both motor and sensory nerves in an uninjured condition and still connected with the spinal cord, seems to be that the irritability diminishes from the central portions outward.

2. *The Influence of a Cut Section.*—The central portions of the nerve of a muscle-nerve preparation are more irritable than the peripheral; this is dependent on the distance from the cut end, and not on the absolute position in the nerve. If a new section be made farther down the nerve, the lower portion of the nerve is made as irritable as that which lay above it. Budge (1860) found in the sciatic of the frog that there were several points of heightened irritability, and that they seemed to correspond to the stumps of divided branches. The facts seem to be explicable by the electrotonic effects due to the currents of rest of the nerve itself. This view was first advanced by Pflüger, and was abandoned because of the small, though perceptible, result obtained by applying the cut end to another nerve, but has been accepted by Hermann.

3. *The Influence of Separation from Nervous Centres and from the Circulation.*—Experiments on this point deal necessarily with the peripheral segments of divided nerves, and (since in sensory nerves there would be here nothing but the currents of action to show stimulation) for the most part with motor nerves. When a nerve is removed from the body it is cut off at once from the circulation and from its connection with nervous centres. In such a nerve the lethal process begins with a rise of irritability (at least for small stimuli), and this is followed by a fall ending in total loss. These processes begin in the upper

part of the nerve and proceed downward (Ritter Valli law), and the proximity to the point of section favors the process.

When nerves are divided inside the body of the living animal, the connections with the nerve-centres are severed without affecting the blood-supply. In this case, also, there is a descending lethal process of the same form as in the excised nerve—that is, with an initial rise and a subsequent fall, and entire loss of irritability. Certain histological changes are observed. First, there is a degeneration of the segments of Ranvier, which have been divided in the operation; then there is degeneration of the entire peripheral segment; the entire nerve, with perhaps the exception of the sheath of Schwann, becomes degenerated and is absorbed. This process does not advance from the centre to the periphery; but opinion is divided as to whether it proceeds in the whole distal segment at once, or whether it advances from the periphery toward the centre. The degenerative processes are advanced by heat and retarded by cold. In warm-blooded animals the degeneration of the white substance of Schwann is noticeable before the fourth day, a considerable time before the entire loss of irritability occurs. The end-organs in some cases degenerate, in others they apparently do not. Neither the retinal rods nor the olfactory end-organs degenerate after section of the corresponding nerves (Krause, Colasanti). The end-plates of motor nerves degenerate (Sokolow; Gessler: "Die Motorische Endplatte," etc., Leipzig, 1885), but there is question about the tactile corpuscles. Vulpian (1870) noticed a peculiar degeneration of the arterioles of the divided nerves.

After section a union of the central and peripheral portions may take place, the myelin being regenerated about the united axis-cylinders. This regeneration seems to depend in marked degree on the influence of the nervous centres. With the anatomical union the irritability returns, and some evidence sustains the conclusion that the internal irritability (conductivity) returns before the external.

Attempts to determine the dependence of the irritability of nerves on the circulation are met by the difficulty that the organs in which these nerves end—muscles, sensory end-organs—are unquestionably more dependent than are the nerves on the blood-supply, and that it is almost impossible to cut off one from the circulation without at the same time cutting off the other.

4. *The Influence of Previous Stimulation, Exhaustion.*—A single moderate stimulus leaves apparently an increased irritability after it. Engelmann (1871) thinks that for a very brief period immediately following a single stimulus the irritability is lowered or lost.

The repetition of a stimulus exhausts the nerve. Bernstein (1877) found that the nerve is exhausted more slowly than the muscle, and also recuperates more slowly. When a tetanizing current is applied to a portion of a nerve until exhaustion ensues, the irritability returns much later at the point of stimulation than elsewhere, so that while a stimulus below this point is followed by a muscular contraction, one above, or at the point itself, has no sensible effect.

The maintenance of a constant current increases the irritability for the openings of the current in the same direction, and for the closing of the current in the opposite direction. The electrodes are not supposed to be moved from their original points of application.

The dependence of the maintenance of normal nervous irritability on functional activity, though frequently asserted, lacks direct proof. Schiff found the peripheral ends of divided sensory nerves undegenerated one and three-fourths year after their section.

Internal Irritability.—In a normal nerve the internal irritability (or conductivity)—the relation of the stimulus which a nerve-element receives from the element on one side to that which it, in consequence, furnishes to its neighbor on the other side—appears to be approximately unity. In other words, the nervous impulse does not, to any considerable degree, increase or diminish in its progress. It would be most remarkable if this relation could not be changed by experimental art or by disease, and it certainly can be so changed. With regard to the effects of temperature and of chemical agents which affect external irritability the testimony is conflicting and very unsatisfactory. If we may, in such a state of things, take the net outcome of the results, it would seem to be rather in favor of, than opposed to, the proposition that, as a general thing, what affects external affects internal irritability in the same direction. For a discussion of this point, see Efron: "Beiträge zur Allgemeinen Nervenphysiologie," *Arch. f. d. Gesammt. Physiol.*, Bd. 36, S. 467, 1885; Ahus: "Die Wirkung des Cocains auf die peripherischen Nerven," *Arch. f. Anat. u. Physiol.*, Physiol. Abth., 1886, Supplement Bd., S. 293; Hirschberg: "In Welcher Beziehung stehen Leitung und Erregung der Nervenfaser zu einander?" *Arch. f. d. Gesammt. Physiol.*, Bd. 39, S. 75, 1886.

We have seen that the exhaustion of a portion of a nerve by tetanizing currents concerns not only its external but also its internal irritability, at the point of application of the stimulus. We have seen, too, that a polarizing current changes the internal irritability in its vicinity. But at present, concerning this most important subject, comparatively little can be positively stated.

James K. Thatcher.

NERVES, REGENERATION OF. Since the days of Fontana the subject of the regeneration or reunion of cut nerves has been one of great interest and importance. All our knowledge at present indicates that fibres of similar functions will unite, that fibres of dissimilar functions will not unite, and that, even in the best-marked cases of regeneration, the functions of the nerve-trunk are never fully restored. There can be no doubt that sensory will unite with sensory fibres, motor with motor, vaso-motor with vaso-motor, etc.; but there are still a few who differ in their belief as to whether fibres of unlike functions will grow together, *i.e.*, sensory fibres with motor, or *vice versa*, etc. The experiments of Bidder with the lingual and hypoglossal nerves, and of Vulpian and Rosenthal with the trunks of the hypoglossal and pneumogastric, led them to believe that sensory fibres had become united to motor fibres. There are still a few physiologists among the Germans who share this conviction, although without adequate foundation.

It is also of interest in this connection to know if fibres of similar function, but of different origin and distribution, could be united, and observations were carried out with this view by the author, in which the trunks of the pneumogastric and hypoglossal nerves were caused to unite. In this experiment the central end of the former nerve was sutured to the peripheral portion of the latter, and as a result, after some weeks, impulses were transmitted from the vagus fibres through those of the hypoglossal, as was evinced in muscular contraction in the side of the tongue corresponding to the parts supplied by the hypoglossal. These contractions were of a peculiar character, occurring only in localized areas, consentaneously with inspiration or expiration, and entirely distinct from normal glossal movements. It is obvious here that impulses which have their origin in the pneumogastric centres and which were intended for laryngeal muscles, were actually carried by the hypoglossal fibres to muscular fibres of the tongue.

The regeneration of divided nerves is hastened by immediate approximation and suture of the cut ends, restoration of functions occurring in such cases much earlier than otherwise; in the former, beginning in from two to four weeks, and in the latter, from four to ten weeks or even later, if at all. When the severed nerves have not been sutured and have failed to unite, reunion may often be established by suturing, even though the time that has elapsed since section is a year or a year and a half. Regeneration is favored in such cases by laying bare the ends of the nerves with a very sharp instrument, such as a razor. Raw silk from the cocoon makes an excellent suture.

Usually sensibility is restored before motion. Nerves during regeneration may fail to show excitability to electrical stimulus, yet be capable of transmitting sensory or

motor impulses. Regeneration of a nerve may occur even after a piece has been excised. Transplantation of nerve has not generally proved successful, although, in animals, reunion has occurred after a piece of nerve from another of different species has been inserted and sutured to the cut ends of the nerve.

(See a paper in the Canada Medical and Surgical Journal of January, 1887, by Dr. Francis J. Shepherd, of Montreal, on Secondary Suture of the Ulnar Nerve, with Rapid Restoration of Sensation.)

Edward T. Reichert.

NERVE-TISSUE. GENERAL.—Nerve-tissue is strictly composed of nerve-fibres and nerve-cells, both held together by a connective tissue of definite structure, either in the central or peripheral nervous system.

Nerve-cells, though varying in form, have certain characters in common. They give origin to a number of processes which divide and subdivide (protoplasm-processes), while other cells may in addition give origin to unbranched processes (axis-cylinder processes) which are considered to be continuous with a nerve-fibre.

Nerve-fibres are now admitted to be connected in the central nervous system with the processes of nerve-cells. This may take place either as above, from an axis-cylinder process, or a nerve-fibre may arise from one nerve-cell, or two or more cells, by the fusion of the fine fibrilla-protoplasm processes of the same, into a primitive axis-cylinder of a nerve-fibre. Nerve-fibres may be regarded as extremely elongated cell-processes (Ranvier) formed of a tissue similar to that of the cell from which they emanate.

Physiologically, a nerve-fibre may be considered as a conducting thread having at one end the nerve-cell, and capable of transmitting impressions from the periphery to the central ganglia (collection of cells), or to convey impulses from these cells to the periphery.

NERVE-FIBRES.—Nerve-fibres may be classed under two leading heads: (1) Medullated or white fibres, and (2) non-medullated, pale, or gray nerve-fibres, according as they do or do not possess a medullary sheath. The same nerve-fibre may at its peripheric termination lose its medullary sheath and become non-medullated, and both varieties of nerve-fibres may be associated in the same nerve-trunk.

Medullated nerve-fibres are found in the vertebrata in the peripheral nerves. In the invertebrate animals the nerve-fibres are of the non-medullated variety. The medullated nerve-fibre may be studied in the living condition in the lung of the frog, or by taking a small nerve from such an animal and teasing it, when fresh, in 0.75 per cent. salt solution. In such a nerve we have the sheath of Schwann, or neurilemma, the medullary sheath, and the axis-cylinder to be considered.

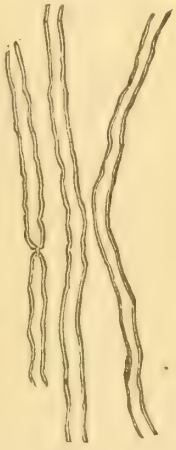

FIG. 2470.—Nerves in the Lung of the Living Frog, showing Constrictions and, at one spot, a Nucleus. × 400 and reduced one-half.

The Axis-Cylinder (Syn., primitive band, cylinder-axis) is a more or less cylindrical structure, with straight contour, running through the centre of the nerve-fibre, round or oval on transverse section. It is very transparent, and in the fresh nerve colorless. Under high powers it is delicately striated. Its substance is firm, though quite pliable, and it is continuous and unbroken throughout the whole course of the nerve-fibre, from its central origin to the periphery. The axis-cylinder varies in size in different nerve-fibres. It remains undivided until the nerve-fibre reaches the peripheric distribution, where it may or may not divide into two or several branches, or finally break up into a number of minute nerve-fibrils. The axis-cylinder can be seen only indistinctly, or not at all, in the fresh nerve-fibre. The fibrillated structure of the axis-cylinder is best seen at the origin of the nerve-fibre in the central nervous system. We may isolate it in nerve-fibres which have been hardened in bichromate salts of ammonium or potash, but it may be seen also in the freshly teased preparation. Here, the nerve-fibre being injured, the axis-cylinder may project somewhat beyond the broken extremity, and then it is seen to be distinctly fibrillated.

If fresh nerves are teased in a solution of nitrate of silver, the axis-cylinder shows at regular intervals a bi-concave enlargement (constrictions of Ranvier): it shows here, also, transverse markings (lines of Frommann) above and below the enlargement. The significance of both of these appearances has not as yet been satisfactorily explained.

The relation of the axis-cylinder to the medullary sheath is best shown in transverse sections of nerves hardened in chromic acid, and stained with picro-carmine, or double-stained with hematoxylin and eosin. The axis-cylinder is seen as a round or oval structure, varying much in diameter in different nerve-fibres. Fine pictures are also obtained in transverse sections of nerves hardened in osmic acid. The sheath of Mauthner is a thin zone of protoplasm formerly described as situated immediately adjacent to the axis-cylinder and separating it from the medullary sheath. It does not stain with carmine, and is regarded as an artificial production. In badly preserved nerves the axis-cylinder is seen to be contracted and star-shaped; this is caused by the pressure of the contracting myelin on the pliant substance of the axis-cylinder.

M. Schultze first called attention to the fibrillated structure of the axis-cylinder. In the periphery these primitive fibrils of the axis-cylinder are seen to present varicose enlargements, and are imbedded in a homogeneous substance in the axis-cylinder.

The Medullary Sheath.—This is a peculiar substance (myelin) of oleaginous consistence, which forms a sheath for the axis-cylinder throughout its course. It is closely applied to the axis-cylinder, and is only separated from it by a lymph-space. It exists in nerve-fibres of the brain and cord, and in the peripheral nerve-fibres. Its substance is perfectly fluid, and of a different index of refraction than that of the axis-cylinder. It is impermeable to fluids, and, on account of its refracting properties, gives the nerve-fibre a dark-bordered or double-contoured appearance. It easily coagulates, and after removal of the nerve-fibre from the body the medullary sheath breaks up into small droplets. The medullary sheath has varying thicknesses in different nerve-fibres; it is interrupted at regular intervals by reflections inward of the sheath of Schwann (to be described), giving a constricted appearance to the fibre at this situation (constrictions or nodes of Ranvier). The medullary sheath at the constrictions is rounded off, and it appears, as a whole, to be divided into segments (interannular segments). The axis-cylinder, however, is continuous across the constrictions of Ranvier. These constrictions are seen in the normal nerve-fibre in the lung of the living frog. The medullary sheath under high power, and in the fresh condition, is seen to be interrupted by shining oblique lines, which run through the whole breadth of the medullary sheath. They may be made more apparent if the nerve be treated with osmic acid. These structures were first described by Schmidt, and are named the incisures of Schmidt.

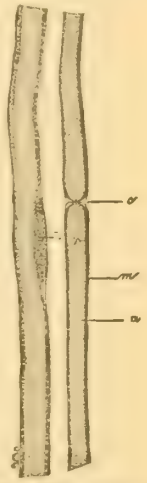

FIG. 2471.—Medullated Nerve-fibres. Osmic Acid Preparation. × 550 and reduced one-half. *n*, Nucleus; *m*, medullary sheath; *c*, constriction of Ranvier; *a*, axis-cylinder.

The axis-cylinder can only be reached, by lymph and crystalloid substances, through the constrictions of Ranvier. To prove this, a nerve is teased in solution of nitrate of silver and then exposed to sunlight. The silver is reduced at the constriction in the form of a cross (crosses of Ranvier). The small bar is transverse, and is at the constriction; the long arm is seen to extend some

distance along the axis cylinder. The silver has thus penetrated through the constriction to the lymph-space beneath the medullary sheath, and between it and the axis cylinder. It shows, also, that a cement substance exists at the constriction which unites the interannular segments and stains with silver, and is permeable to similar fluids.

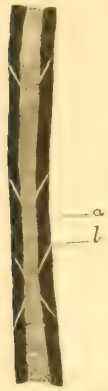

Fig. 2472.—Nerve-fibre teased in Osmic Acid (0.5 per cent.), from the Sciatic Nerve of the Rabbit. × 750 and reduced one-half. *a*, Medullary segment; *b*, incisures of Schmidt.

Lantermann's Segments. When the nerve-fibres are treated with a 0.5 per cent. solution of osmic acid, the medullary sheath breaks up into a number of segments (conico-cylindrical segments), which are marked off from one another by the incisures of Schmidt. The axis cylinder is continuous through them. The significance of this division of the medullary sheath is not known. When the nerve-fibre is hardened in chromate of ammonium or osmic acid, the medullary sheath appears as though composed of a number of fine rods (Lantermann). Kühne and Ewald contend that these rods form a sort of network, which stretches between the sheath of Schwann and a sheath described as directly around the axis cylinder. All these appearances must be looked on as artificial. A sheath around the axis cylinder has also been described by Remak; its existence is highly problematical. Ranvier describes a thin layer of protoplasm in the medullary sheath, which is adjacent to the axis cylinder; another such layer is thought to be directly beneath the sheath of Schwann, and small septa of protoplasm stretch between the two layers separating the conico-cylindrical segments. The medullary sheath is composed of substance which, when it escapes from the nerve-fibre, forms in drops which have a double contour. When these drops come in contact with water they swell up and take on a concentrically striated appearance.

Sheath of Schwann (primitive sheath, neurilemma) is a transparent membrane of homogeneous structure, which is closely applied to nerve-fibre and surrounds the medullary sheath. It is highly elastic, resists the action of reagents, as acetic acid, potassium hydrate, and ether, and is not so easily broken as the oily myelin. In the fresh nerve-fibre it cannot be demonstrated, and is only seen in injured nerve-fibres to pass from one segment of myelin to the adjacent one. This sheath of Schwann is continuous across the incisures of Schmidt, and at the constrictions of Ranvier it approaches the axis cylinder, being reflected inward for some distance along the axis cylinder. The medullary sheath is thus divided up by the sheath of Schwann into segments, which are thought to be joined together by cement substance. The sheath of Schwann has not as yet been demonstrated to exist in the medullated nerve-fibres of the brain and spinal cord, or in the nerve-fibres of the optic nerve. On the inner surface of the sheath of Schwann, and about midway between two constrictions of Ranvier, is seen the nucleus of the nerve-fibre. These nuclei, one to each interannular segment, are quite large, oval or spheroidal in shape, and surround the nerve-fibre for fully two-thirds of its circumference. They are granular, surrounded with a pale zone of protoplasm at each extremity; they cause the contour of the nerve-fibre to bulge at the points where they are situated. These nuclei are accommodated in a concavity of the myelin of the medullary sheath. Sometimes the borders of the nucleus have a festooned appearance, and it may also contain drops of myelin.

The segment of neurilemma between two constrictions of Ranvier, with its nucleus, may be regarded as an elongated cell (Ranvier) cemented to its neighbor at a constriction. The nuclei are demonstrable with picro-carmine or aniline red. To demonstrate the sheath of Schwann the medullary sheath may be dissolved by glacial acetic acid, chloroform, or ether. The relation of the nucleus to the nerve-fibre is best seen in transverse sections of small nerves (sciatic of rabbit) preserved in chromic acid and stained with hematoxylin, and eosin or picro-carmine (see Fig. 2476). In some fishes (electric eel) the interannular segment may show more than one, sometimes from three to seven nuclei.

Measurements of nerve-fibres (Key, Retzius) in man. Nerve-fibres medullated: breadth, 0.002 to 0.0168 millimetres; nucleus, 0.008 to 0.016 millimetre; interannular segments, 0.0896 to 0.9624 millimetre.

Non-medullated Nerve-fibres.—Fibres of Remak, pale or gray nerve-fibres, are found chiefly in the sympathetic system of nerves, or they may be found in the peripheral cerebro-spinal nerve-trunks, associated with medullated nerve-fibres. They are destitute of a medullary sheath, and occur as thin, transparent, pale or grayish fibres, without any double contoured appearances. They are indistinctly and delicately striated. They anastomose with each other, forming networks the meshes of which are elongated in the course of the nerve-fibres. On the surface of the fibres of Remak are seen their nuclei, spindle-shaped, granular, and surrounded at each extremity by a very transparent zone of protoplasm. These nuclei are on the surface, from which they are seen to project in places. The presence of a sheath similar to that of the neurilemma has not as yet been fully demonstrated; the nuclei are regarded by some writers as evidence of the existence of a sheath of exceeding thinness (Schwalbe). The striation of these fibres adds to the belief that they are made up of a number of nerve-fibrils. Non-medullated nerve-fibres exist which are not striated on the surface, and are of homogeneous appearance. A form of non-medullated nerve-fibre exists in the central nervous system, as a direct process from a nerve-cell. They may run undivided for some distance, or may finally divide into many branches; these are called naked axis cylinders. The axis cylinders of medullated nerve-fibres may lose their medullary sheath at their peripheric termination, and divide and subdivide, forming intricate networks of primitive fibrils which show a varicose contour, as in the cornea. These nerve-fibrils possess neither medullary sheath nor sheath of Schwann. Non-medullated nerve-fibres, if hardened in bichromate of ammonium, are seen to be made up of a number of fibrillæ with varicosities along their course; these appearances must be regarded as artificial. The olfactory nerves are made up of non-medullated fibres which have a distinct nucleated sheath.

Fig. 2473.—Fibres of Remak, from the Pneumogastric of the Dog. Osmic acid preparation. (Ranvier.) *n*, Nucleus; *p*, protoplasm surrounding it; *b*, striæ.

To avoid confusion it should be noted that the term neurilemma, now applied to the sheath of Schwann, was formerly bestowed on the connective tissue surrounding the *nerve-trunk*.

Nerves are composed of a number of nerve-fibres bound together by connective tissue of peculiar structure to form fascicles. A nerve-trunk may be made up of only a single fascicle of nerve-fibres, covered by a connective-tissue sheath, or it may be made up of several such fascicles. In a nerve-trunk made up of only a single bundle of nerve-fibres, the connective tissue on the outside of the nerve is loose in texture and unites the nerve to the surrounding structures (perifascicular connective tissue); beneath this, and enveloping the nerve in the manner of a sheath, the connective tissue is disposed in a denser and more lamellated arrangement, and is called the lamellar sheath. From this sheath processes of connective tissue are sent into the nerve-trunk, to be distributed between the individual nerve-fibres (intra-fascicular connective tissue).

The lamellar sheath, in its simplest form, is seen in the smallest nerves made up of a single nerve-fibre; such as are found in the dorsal lymph-sac of the frog toward the peripheric termination of a nerve. Here the lamellar sheath consists of a homogeneous connective-tissue tube, which, by special silver manipulation, is seen to be lined on its inner surface by a single layer of endothelial cells with oval nuclei; these cells have sinuous outlines. The sheath in this form has been named the sheath of Henle (Ranvier). There is a space between the nerve-fibre and the sheath, and this is filled with lymph in the recent state. In larger trunks this simple structure is replaced by a lamellar sheath composed of many lamellæ. In a nerve like the sciatic of the rabbit, the superficial lamellæ are composed of fibres of fibrillated connective tissue, interlacing to form a dense membrane and granules of elastic tissue. The deeper layers are more delicate in structure and exceedingly thin; all the lamellæ are lined by endothelial cells. The lamellæ are not independent, but compactly arranged and connected to each other by longitudinal processes. When a nerve-trunk divides the deeper lamellæ are reflected inward and divide the nerve-trunk into two fascicles, while the outer lamellæ persist to form a common sheath for both nerve-bundles. Blood-vessels supply the lamellar sheath with blood.

Fig. 2474. — Small Nerve from the Lumbar Plexus of the Frog, stained with Nitrate of Silver, and showing the Sheath of Henle.

The *perifascicular* connective tissue is of the loose variety found beneath the skin. It is composed of fibrillated and elastic fibres in the meshes of which are found flat and branching connective-tissue cells, fat-cells, blood-vessels, and lymphatics. The fibrillated fibres run for the most part in a longitudinal direction, the elastic network forms elongated meshes in the axis of the nerve, and the fat-cells are arranged in groups longitudinal with the direction of the nerve. Adjacent to the nerve-trunk this tissue resembles in structure that of the lamellar sheath. The *intra-fascicular* connective tissue is composed, first, of lamellæ derived from the lamellar sheath, which divide the nerve-trunk into two or more fascicles, or which conduct blood-vessels. The intra-fascicular tissue is also found in the form of very delicate fibrillated fibres of connective tissue and flat, irregular, branching cells, very much resembling those of the subcutaneous tissue. The above fibres run with the nerve-fibres and surround them, forming elongated meshes, in which we find the above cells. Lymphoid cells are also found here.

Fig. 2475.—A Nerve composed of a Single Fibre in its Sheath of Henle, from the Dorsal Lymph-sac of the Frog. (Osmic acid, alcohol, and H_2O.) × 550 and reduced one-half. *a*, Nerve-fibre; *b*, sheath of Henle; *n*, nucleus of sheath of Henle.

Blood-supply.—The minutest nerves do not possess any blood-vessels of their own; they are nourished by the lymph by which they are surrounded, and which they derive from the capillaries of the surrounding structures. In nerves of greater size the blood-vessels are seen to ramify in the lamellar sheath in groups or separate trunks, and from here they penetrate into the interior of the nerve. If a small nerve be injected in a mammal, we find an abundant plexus of arteries, veins, and capillaries in the perifascicular tissue and lamellar sheath. The meshes of these vessels are arranged longitudinally to the nerve. From these, vessels penetrate into the interior and surround the nerve-fibres by an abundant, long-meshed capillary plexus, the different branches of which are connected by transverse trunks. In transverse sections of nerves the arterioles and veins are seen to be mostly situated in the larger trabeculæ of intra-fascicular connective tissue, and from these capillaries are derived, to be distributed around the individual nerve-fibres.

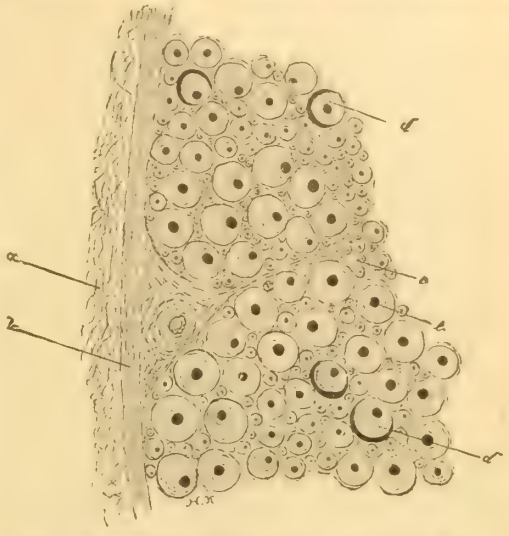

Fig. 2476.—Transverse Section of the Sciatic Nerve of the Rabbit, hardened in Chromic Acid and stained with Picro-carmine, and showing Lamellar Sheath, Peripheric Connective Tissue, and Intra-fascicular Connective Tissue. × 550 and reduced one-half. *a*, Perifascicular connective tissue; *b*, lamellar sheath; *c*, intra-fascicular connective tissue; *d*, nerve-fibre cut across, showing nuclei of same; *e*, axis cylinder.

Lymphatics.—From the present methods of research, it has been well established that the lymphatic *vessels* do not penetrate into the interior of the nerve-fascicle. The lymphatics take their origin in the meshes of the perifascicular tissue by wide mouths, and, ramifying here in the longitudinal axis of the nerve, empty into the larger lymphatics in the neighboring structure. The individual *nerve-fibres* are bathed and nourished by an abundant nutritive plasma, which exudes from the intra-fascicular plexus of capillary blood-vessels. This plasma penetrating the fenestræ of the lamellar sheath, is collected by the lymphatic radicals of the perifascicular tissue, and thus reaches the general lymph-circulation. The nutritive lymph bathes each fibre, and gains the axis cylinder through the constriction of Ranvier.

Fig. 2477.—Division of a Nerve-fibre, with its Sheath of Henle, from the Dorsal Lymph-sac of the Frog. × 550 and reduced one-half.

Division of Nerve-fibres.—Nerve-fibres, while contained in their respective fascicles or nerve-trunks, do not, as a rule, divide. When nerves form frequent inosculations, as in the cervical and brachial plexuses, the *nerve-fibre* simply passes from one trunk to another, but remains undivided. When a nerve reaches the region of its terminal distribution, it is generally composed of a small number of nerve-fibres, two or more, or even of a single fibre. This is surrounded by a simple connective-tissue sheath (sheath of Henle). These simple nerves are best adapted for study; here the medullated nerve-fibre is seen to divide at a constriction of Ranvier, retaining at first its sheath of Henle, and neurilemma and medullary sheath. The division is

dichotomous. On repeated subdivision, the neurilemma and medullary sheath disappear, and the axis cylinder alone persists (naked axis cylinders) as in the cornea. At this stage the axis cylinder may further divide, and finally break up into a number of very minute nerve-fibrils, which have a characteristic varicose appearance, and end in bulbous or pointed free extremities. They can be distinguished from connective-tissue fibres, and stain with gold chloride. Nerve-fibres may divide also, in a manner similar to the above, in the central nervous system. In fishes, as the electric eel, one medullated fibre may divide into innumerable branches.

Development of Nerve-fibres.—Balfour and Marshall, who studied the embryos of elasmobranch fishes and chicks, concluded that nerves, nerve-roots, and ganglia develop as cellular outgrowths from the rudimentary central nervous system. They infer that the same is probably the case in mammalia. The central nervous system is formed by the involution of the ectoderm or epiblast along the mid-line of the embryo. Nerve-cells and fibres of the central and peripheral nervous system are developed from the ectoderm. Neuroglia is of doubtful origin; Kühne and Ewald refer its development to the ectoderm. The greater number of writers agree that nerve-fibres develop from the centre toward the periphery. M. Vignal found that in embryo calves and sheep nerve-fibres first appeared as fascicles composed of fine fibrils and granules arranged side by side, and imbedded in a homogeneous substance. The periphery of these fascicles is covered by embryonal connective-tissue cells which proliferate later on and penetrate into the interior of the nerve-fascicle, dividing it into smaller ones. At this time we see a nerve-fibre as a bundle of fibrils which lie in a homogeneous substance (axis cylinder) covered with a sheath. Later on (fourth month) the myelin appears in the protoplasm surrounding the axis cylinder. At first scarcely perceptible, it appears as a thin lamella which extends the whole length of the interannular segment. Again, it may appear in the form of globules or granules distributed along the course of the nerve-fibre. From this point it develops, and finally attains its character seen in the adult animal. Nerve-fibres do not develop at one and the same time throughout the body, but in a definite order along certain tracts (Flechsig).

Degeneration and Regeneration of Divided Nerves.—*Degeneration:* If a nerve be cut across, the divided extremities, when apposed, will unite by means of cicatricial tissue, but the nerve-fibres themselves do not unite. About twenty-four hours after the section of the nerve-fibres the sheath of Schwann becomes visible, the nuclei enlarge, and protoplasm is seen to accumulate at the nuclei and nodes of Ranvier, at the expense of the medullary sheath. This accumulation takes place also at other points along the nerve-fibre corresponding to the intervals between the medullary segments (Ranvier). After a while the collections of protoplasm, containing granules and droplets of myelin, interrupt the continuity of the medullary sheath. On the fourth day the nuclei of the sheath of Schwann are seen to be slightly increased in number, and the whole myelin is broken up into large and small drops. The axis cylinder becomes interrupted at numerous places, leaving a few short fibres to be seen curled up at their ends and enclosed in large drops of myelin. Eventually these disappear, as does also the medullary sheath, with the exception of a few residual drops of myelin.

The sheath of Schwann is finally occupied by a granular mass of protoplasm containing an increased number of nuclei. During the above changes the connective-tissue cells in the vicinity become charged with granules of fat, apparently derived from the myelin sheath. These changes occur along the whole length of the peripheral portion of the divided nerve-fibre. In a motor nerve the end plate is said to be the first structure affected. In the immediate vicinity of the section the myelin escapes from the central and peripheral ends of the nerve-fibre, and blood and lymph replace the myelin in the sheath of Schwann up to the first node of Ranvier. Otherwise the central end of the nerve-fibre undergoes no change; it may swell slightly and one or two nuclei of the neurilemma may proliferate, but nothing beyond this is observed.

Regeneration: Reproduction of new in place of the old nerve-fibres which have undergone degenerative changes, is a slower process than that detailed above. Up to the twenty-eighth day after section of the nerve-fibre nothing indicating reproduction is seen. Transverse sections of a degenerated nerve at this time show the sheath of Schwann filled with a clear or finely granular substance. After from sixty to seventy days small pale or medullated fibres, singly or in groups, are seen in the tubes of the old medullary sheaths or between them. Here and there the old drops of unabsorbed myelin persist from the original medullary sheath. These groups of new fibres are seen to be continuous with the central extremity of the axis cylinder of the original nerve-fibre. An axis cylinder may give origin to two or more fibres, but these in turn bifurcating and subdividing, will form bundles of some size. Thus regeneration takes place by an outgrowth of fibres from the central end of the cut axis cylinder, and it takes place from the node nearest the point of section, or one slightly removed from it. In number they exceed the original nerve-fibres, and they are first pale, becoming subsequently possessed of a medullary sheath.

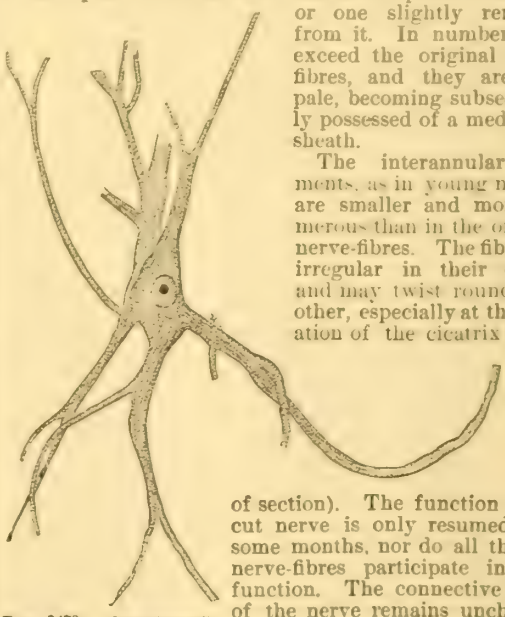

Fig. 2478. — Ganglion-cell from the Anterior Horns of the Spinal Cord of the Ox. Carmine preparation. × 120 and reduced one-half.

The interannular segments, as in young nerves, are smaller and more numerous than in the original nerve-fibres. The fibres are irregular in their course and may twist round each other, especially at the situation of the cicatrix (point of section). The function of the cut nerve is only resumed after some months, nor do all the new nerve-fibres participate in such function. The connective tissue of the nerve remains unchanged during degenerative and regenerative processes, except at the point of section. At the cicatrix the nerve-fibres become finally surrounded by definite sheaths, and the complete continuity of the divided nerve is restored. The integrity of the central portion of a nerve-fibre is preserved through the influence of certain collections of nerve-cells (trophic centres) in the spinal cord, for nerve-fibres derived from the anterior nerve-roots, and through that of (spinal) ganglia on the nerves themselves, for those coming from the posterior roots of the spinal cord. According to the theory of S. Mayer, degeneration and regeneration are constantly occurring as steps in a normal process, but the continuity of any one nerve-fibre is not impaired thereby, and thus we have a constant renewal of the nerve-fibres in the animal economy.

Nerve-cells. — Nerve-cells, or ganglion-cells, are structural elements of the nervous system which have a distinct cellular structure, and are met with in the gray matter of the brain and cord, their ganglia, in certain peripheral nerve-terminations, and also in certain places in close connection with nerve-fibres.

They are of most varied form—ovoidal, spheroidal, or branched, but in certain regions may be in general said to have a peculiar and characteristic shape. In the cortex of the brain there exist cells of a pyramidal form with several processes at their base. In the cortex of the cerebellum the peculiar Purkinje cell exists. This has a

flask-shaped body with processes similar to the antlers of a deer; it gives off from its base an unbranched process (axis cylinder process), thought to be continuous with a medullated nerve-fibre. In the sympathetic nervous system the cells are more rounded in shape.

The cell body of a ganglion-cell is finely granular and delicately fibrillated in structure; it may contain fine granules of refracting pigment, more marked in cells of the adult mammalia. These granules may be single or appear in clusters. In some, especially the lower animals, droplets of fat are seen. The nucleus is in the fresh condition a clear, transparent vesicle, ovoidal or spheroidal in form, and in its interior may be seen an intra-nuclear network and a very refracting nucleolus. In size they rank among the largest cellular elements of the body, varying in the same regions of the central nervous system. In the cord of man the largest (over one hundred micromillimetres in diameter) are found in the anterior horns of gray matter. In the cerebellum they reach fifty micromillimetres in diameter. Smaller cells occur in the sympathetic ganglia and peripheral nerve-terminations. The branched cells send off processes in every direction from the cell body. Into these processes the protoplasm of the cell body is continuous (protoplasm processes). From the number of its processes a cell is called unipolar, bipolar, or multipolar. Apolar cells, if they exist, have not been satisfactorily demonstrated, and those taken hitherto as such are embryonal cells or cells injured through manipulation. The processes may be homogeneous, but they are mostly finely granular and delicately striated, especially in man. In the multipolar cells we find sometimes one process which remains unbranched, and is seen to originate from the vicinity of the nucleus of the cell body (axis cylinder process). These axis cylinder processes have been described as becoming continuous ultimately with a medullated nerve-fibre. The branched processes form networks with the processes of other cells, and their ultimate fibrils, uniting with those of other cells, form into bundles which are subsequently covered with a medullated sheath, and thus form the axis cylinders of nerve-fibres. Thus, nerve-cells and nerve-fibres are inseparable anatomically and physiologically. The cells of the brain and cord have no cell-membrane, but in the cerebro-spinal and sympathetic ganglia such a membrane is demonstrable. Here in the unipolar cells this capsule is delicately striated, nucleated on its inner surface, and closely surrounds the cell body. The capsule is seen to be continuous with the sheath of Schwann of the nerve-fibre.

FIG. 2479.—Small and Large Ganglion-cells from the Cortex of the Human Cerebrum. × 550 and reduced one-half.

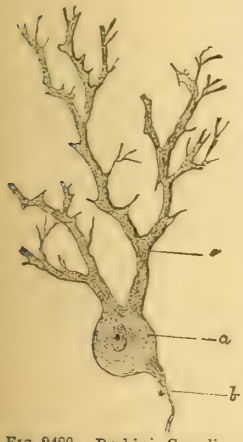

FIG. 2480.—Purkinje Ganglion-cell from the Human Cerebellum. *a*, Cell body; *b*, pointed axis cylinder process; *c*, antler-like processes.

Ganglia.—Ganglia are circumscribed swellings situated in the course of nerves, and consist of cells intermingled with or continuous with nerve-fibres. If the nerve-cells are very numerous, then the ganglion has some appreciable size—and may be ovoidal, spheroidal, elliptical, or irregular in shape. It may surround the nerve or be placed to one side of it. Some ganglia are microscopic in size; such occur in the viscera or trunks of nerves, especially of the sympathetic nerves. The general features of ganglia of some size are, a capsule continuous with and similar in structure to the connective tissue surrounding the nerve-trunk to which the ganglion belongs. From the capsule delicate trabeculæ are sent internally between the bundles of nerve-fibres, and nerve-cells. The latter may be arranged in rows along the course of the nerve-fibres or in groups. The nerve-fibres are collected into bundles, and the majority of them are not connected with the nerve-cells; but the nerve-cells are seen to give origin to nerve-fibres. A rich capillary plexus of blood-vessels ramifies among the ganglion-cells, surrounding each cell separately. All ganglia are classified under the two following heads:

FIG. 2481.—Ganglion-cell from the Abdominal Sympathetic of the Frog. Osmic acid preparation. × 850 and reduced one-half. *a*, Cell body; *b*, capsule; *p*, process.

Spinal Ganglia. These include the ganglia on the posterior nerve-roots, the Casserian ganglion, those of the acoustic, pneumogastric, and facial nerves (geniculate ganglion). They consist of the above capsule and trabeculæ. The ganglion-cells have a capsule lined on its inner surface with a layer of nucleated cells, the protoplasm of which is very granular. The cell body of the ganglion-cell may not completely fill its capsule, and the cells may be small or large, spheroidal, ovoidal, or flattened. They possess one process (unipolar), as a rule, which may eventually become continuous with a medullated nerve-fibre. This fibre may, in turn, divide in a T-shaped manner (Ranvier), at a constriction of Ranvier. Some authors have observed bi- and multi-polar ganglion-cells here, others deny that these are present. In the lower animals multipolar cells are common.

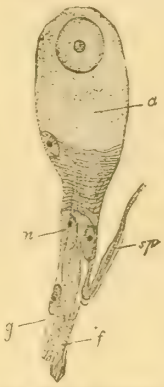

FIG. 2482.—Ganglion-cell from the Pneumogastric of the Frog. Osmic acid preparation. (Ranvier.) *a*, Ganglion-cell body; *f*, straight fibre; *g*, sheath of Henle; *n*, nucleus of this sheath.

Sympathetic Ganglia. This group includes ganglia connected with the sympathetic system of nerves, both in the head and trunk, as also the ganglia of the trigeminus. The arrangement of connective tissue, capsule, and trabeculæ is the same as in spinal ganglia. The ganglion-cells are smaller, as a rule, and are rounded, oval, or pear-shaped. The cells are mostly multipolar in form, with processes of varying thickness. They have a capsule, the inner surface of which is lined with cells which are more endothelial in character than those of the spinal ganglia. This capsule is continuous with the sheath covering the processes. Soon after leaving the capsule the processes proceed to divide and subdivide into non-medullated fibres, which ramify among the ganglion-cells. In man they do not become possessed of a medullary sheath, but in the frog this has been seen to be the case. Around the above cells numerous apolar cells are seen, which are said to be developing forms.

The *Ganglion-cell* with a *spiral* fibre-process. An important factor in the sympathetic ganglia of the frog is a

ganglion-cell, which has in addition to its straight process another, which winds spirally around the same for a greater or shorter distance (Beale, Arnold, Ranvier). In the pneumogastric of the frog this cell has a capsule lined with flat nuclei; the cell body is granular, with a spherical nucleus. Around the rectilinear process the capsule is continuous as a sheath, which is nucleated and at a point more or less distant from the cell body. The spiral fibre enters the sheath, and then winds around the straight fibre in close turns, reaching the cell body in the form of a helix.

Neuroglia.—The term neuroglia is specially applied to a delicate form of connective tissue of peculiar structure which forms the supporting framework for the nervous elements in the central nervous system. It may be described as being composed of fibres and cells. The fibres are of great length and interlace with each other. In the midst of these fibres lie the cells (Deiter's cells, spider cells, neuroglia cells). These structures in the spinal cord and brain are situated between the nerve-fibres and cells, and form a supporting framework for them. The fibres and cells are closely connected, the former being considered prolongations simply of the latter. The cells in the spinal cord are flat and membranous, with a distinctly fibrillated cell body and a prominent nucleus (Ranvier). These cells give origin to numerous processes which are delicately fibrillated, and which are looked on as protoplasmic prolongations of the cell body. These processes may be traced into the cell body, where they are finally lost. The above-mentioned fibres of the neuroglia are continuous with these processes. Thus the general shape of the cell has been described as star-shaped, some with projecting nuclei. The existence of elastic granules described by some writers (Schwalbe), in addition to neuroglia fibres and cells, is considered by

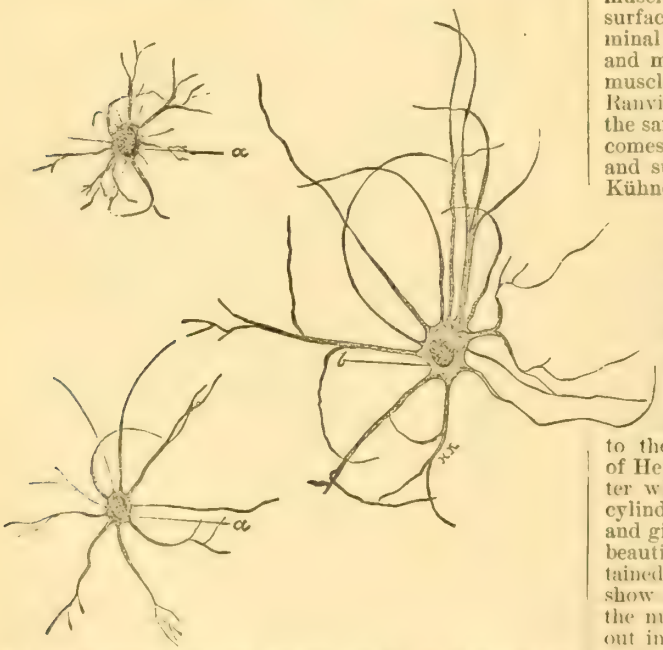

Fig. 248.—Neuroglia Cells from the Spinal Cord of the Ox, and from the Cortex of the Human Cerebrum. × 850 and reduced one-half. *a. a.* Cells from the cortex of the human cerebrum; *b*, cell from the spinal cord of the ox.

others as referable to imperfections in manipulation. Schwalbe regards the fibres of the neuroglia as derived from a substance which during life exists between the nerve-fibres, has a semi-fluid consistency, and is homogeneous in character, coagulating post mortem, and appearing after the action of hardening fluids fibrillated in structure. In the cortex cerebri of man the neuroglia cells have a spheroidal nucleus with a small cell body and the above-described processes.

Nerve-cells and the cells of the neuroglia are of very similar structure, both having fibrillated cell bodies and fibrillated protoplasm processes. They are thought to have a common origin.

Nerve Terminations.—In the central nervous system nerve-fibres terminate, as above described, in nerve-cells. In the periphery the terminations vary with the function of the nerve-fibre (motor or sensory).

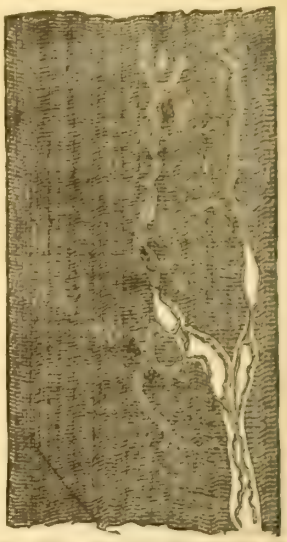

Fig. 248.—Terminal Distribution of a Motor Nerve. (Ranvier.)

Terminations of Motor Nerves.—In striated voluntary muscle, immediately after the entrance of a nerve in a muscle, it divides and subdivides into smaller and smaller branches, from which minute nerve-trunks originate, to be distributed in an oblique or transverse direction to the surface of a muscle-fibre. In this manner a plexus of fine nerves is formed by the division and subdivision of larger trunks inside the perimysium. When a nerve comes in direct relation with a single muscle-fibre, it, as a rule, consists of a single medullated nerve-fibre with its sheath of Henle. This nerve-fibre is brought in direct contact with the muscle-fibre, by means of an expansion applied to the surface of the latter, called the motor end-plate or the terminal arborization of Ranvier. In birds, reptiles, fishes, and mammalia, the nerve-fibre, at its attachment to the muscle-fibre, may or may not divide at a constriction of Ranvier. Its sheath of Henle becomes continuous with the sarcolemma of the muscle-fibre. The axis cylinder comes in direct contact with the sarcous elements, divides and subdivides, forming the above arborization, or what Kühne and others describe as the end-plate. This arborization (end-plate) is raised above the surface of the muscle-fibre and has an elongated oval shape. The branches of this terminal arborization present alternate constrictions and swellings, and are sinuous, but sharply outlined. An axial and peripheral zone is discernible, the latter being more refracting than the surrounding tissues. The branches terminate by pointed or rounded extremities. In the arborization and along the borders of its branches are situated small irregular nuclei with nucleoli. Other nuclei, with no definite relation to the arborization, exist, which belong to the sheath of Henle, covering the end-plate, or to the granular matter which surrounds the terminal branches of the axis cylinder. The granular matter mentioned above is pale and gives the end-plate a punctate appearance. The most beautiful results in the above end-plates have been obtained by the gold methods of Lowit or Ranvier. They show the ultimate nerve-fibre and arborization, but not the nuclei or granular matter. These can best be made out in preparations treated with osmic acid. Here the nuclei of the sheath of Henle are seen, those of the granular matter and those of the branches of the arborization. The ultimate disposition of the *sheath of Schwann* is still in doubt. It is probably reflected over the branches of the arborization. The branches of the arborization do not anastomose with each other in reptiles and fishes, but in mammalia this may occur.

In striated involuntary muscle (heart) an abundant quantity of anastomosing nerve-fibres are given off from the cardiac plexus, which are distributed along the course of the coronary vessels. This rich plexus is reinforced by groups of microscopic ganglia. The nerve-

fibres are partly of the medullated and partly of the non-medullated variety. The ganglion-cells are, as a rule, bipolar, but in the frog and rabbit some of them have in addition to their straight a *spiral* fibre-process. The exact mode of termination of the nerve-fibre in the muscle-cell is not as yet established. End-plates have not been observed, nor is it known whether the nerve-fibre penetrates the muscle-cell or not. Ranvier concludes that in the frog or turtle the ultimate nerve-fibrils penetrate the muscle-cells and traverse them in a longitudinal direction.

Smooth Muscle-fibre. The nerves, before they reach the muscle-fibre, form a rich plexus from which bundles of non-medullated nerve-fibres originate. The latter again divide and subdivide, and form a second plexus called the intermediate plexus. In the intestine we have collections of ganglion-cells in the meshes of the plexus of nerve-fibres. From the above plexus fine pale fibres are given off, running parallel to the muscle-cells, which branch and divide and penetrate between the muscle-cells; thus giving an intra-muscular plexus. From this last plexus very fine fibrils penetrate the muscle-cells, and are said to traverse the nucleus and end in the nucleolus, in bulbous extremities. Arnold considers the nucleus simply traversed by the ultimate nerve-fibril, which again emerges from the muscle-cell to take part in the intra-muscular plexus. Lowit describes the nerve-fibrils as ending in the substance lying between the muscle-cells, opposite the situation of the nucleus.

Terminations of Sensitive Nerves.—Aside from nerves which terminate in intricate sensory expansions, as the retina, etc., we have a number of nerves in the more superficial regions of the body, as the skin, which are principally concerned with touch and temperature. These sensitive nerves of the skin may terminate in any of the following ways:

1. In parts of the body covered by stratified epithelium, as the skin, mucous membrane of the mouth, and cornea,

FIG. 2485.—Termination of Nerve Filaments in the Epithelium of the Cornea. (Ranvier.)

the nerve-fibres, after losing their medullary sheath, form plexuses; the fibres given off from these plexuses may subdivide, forming secondary and even tertiary plexuses from which fine fibrils are given off to end between the epithelial cells in blunt or pointed extremities. In the cornea the medullated nerve-fibres, after penetrating the deeper layers of the cornea, lose their medullary sheath and become naked axis cylinders. The latter ramify and form a coarse plexus in the deeper layers of the corneal tissue. From this plexus branches originate to ramify in the superficial layers of the cornea and form a delicate plexus directly beneath the anterior elastic lamina (sub-basal plexus). In this plexus the axis cylinders divide into the finest nerve-fibrils, which perforate the anterior elastic lamina, and form a fine meshed network in the deeper layers of epithelial cells covering the cornea (sub-epithelial plexus). From the latter a number of very fine nerve-fibrils are given off and ramify between the epithelial cells of the more superficial strata of epithelium. These fibrils finally terminate in pointed or bulbous extremities *between* the epithelial cells of the cornea.

Another mode of termination of nerve-fibres in the epithelial surfaces is described by Langerhans, who found in the deeper layers of the stratum Malpighii stellate cells with branched processes. These he thought were connected with the nerves of the cutis by means of fine processes. These cells are regarded as analogous to ganglion-cells, and as forming some peculiar termination of the sensitive nerves of the skin. Hensen has described intra-epithelial nerve-endings in the frog. The nerve-fibrils are here said to end in the nucleus or nucleoli of the cell. Pfitzner and Unna have also described such nerve-endings in salamanders and the stratum Malpighi of man, but this mode of nerve-termination remains in doubt.

FIG. 2486.—Tactile Cells. *A*, Grandry's corpuscles; *B*, cylindrical terminal bulb of the conjunctiva of the calf. Osmic acid preparation. (Toldt.)

2. *Tactile cells* of Merkel; *Grandry's corpuscles.* Both the above are best seen in the soft skin covering the bills of birds. The corpuscle of Grandry consists of delicately punctate, and sharply defined cells, which are flattened and lens-like in form, and have a nucleus (tactile cells of Merkel). They occur singly or in groups of two, three, or four, surrounded by a connective-tissue nucleated capsule (Grandry's corpuscle). The cells are separated by a disk-like structure (tactile disk), which receives the termination of the axis cylinder of the afferent nerve. Thus these tactile cells, or groups of cells, provided with the above capsule, receive each an ultimate medullated nerve-fibre. The sheaths of Henle and Schwann become continuous with the capsule, and the axis cylinder breaks up into fibres which are lost in the tactile disks. These corpuscles are thought to be developed from cells at the apices of the papillæ of the skin, which in course of development become isolated and surrounded by a capsule, and finally supplied with a nerve-fibre.

3. *Tactile corpuscles* (Meissner's or Wagner's corpuscles). These are ellipsoidal, sharply defined bodies, which have a transverse superficial striation; they measure 40 to 200 μ in length by 30 to 60 μ in width. They are found in the papillæ of the skin, the palmar surface of the finger of the hand, and plantar surface of the toes of the feet. They are less numerous in the skin of the dorsum of the hand or foot, the nipple of the breast, lips, tip of the tongue, and tarsal region of the conjunctiva. They are best studied in gold chloride preparations (Fleming, Fischer, Ranvier). They almost fill up the space of the papilla (having an enveloping membrane), and may consist of one, two, or three lobes (Thin). The ultimate nerve-fibre reaching the tactile corpuscle may divide into several branches (at a node of Ranvier), each of which supplies a lobe of the corpuscle. On reaching the interior of the corpuscle the nerve-fibre breaks up into a number of twigs which, as a rule, are transversely arranged to the axis of the tactile corpuscle. These twigs may dispose themselves obliquely or longitudinally, but whether transverse or otherwise, they arrange themselves in groups (bouquets glomérulés, Ranvier), and thus give to the whole body a lobular ap-

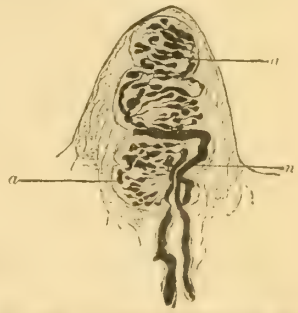

FIG. 2487.—Tactile Corpuscle from the Skin of the Palmar Surface of the Index-finger of Man. (Ranvier.) Gold preparation; longitudinal section. *a*, Cluster of terminal nerve-fibrils (*bouquets glomérulés*); *n*, afferent nerve-fibre.

pearance. In the periphery of the tactile corpuscles are seen slightly flattened nuclei of cells, which are supposed to send out processes (protoplasm process) to ramify the groups of nerve-fibrils.

Tactile Cells (Ranvier).—The form of these cells is not yet definitely established, but they are not connective-tissue cells. Merkel regards them as a variety of tactile cell which receives the termination of the axis cylinder of the afferent nerve-fibre.

End-bulbs. (*a*) Spherical (Krause); (*b*) Cylindrical.

(*a*) *Spherical End-bulbs.*—These end-bulbs stand intermediate in structure between the tactile and Grandry corpuscles. They are found in man and higher order of monkey. In the former they occur in the conjunctiva bulbi, lips, mucous membrane of the tongue, cheeks, and posterior wall of the pharynx, rectum, glans penis, and clitoris. They are situated in the superficial layers of connective tissue adjacent to the epithelium, and consist of a capsule of connective tissue which is nucleated. This capsule encloses a finely granular protoplasm with rounded or flattened nuclei. Each bulb may receive one or more nerve-fibres, the sheath of Henle becoming continuous with the capsule of the body. The axis cylinder terminates in the interior in cells much similar to the tactile cells of Merkel; these cells are situated in the

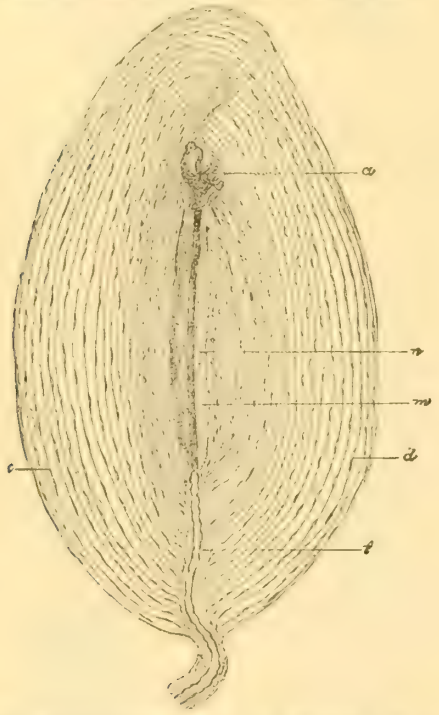

FIG. 2488.—Pacinian Corpuscle from the Mesentery of an Adult Cat. (Ranvier.) *c*, Capsules; *d*, endothelial markings; *n*, afferent nerve; *m*, elongated central cavity; *f*, funiculus; *a*, terminal fibres.

above-mentioned protoplasm (Waldeyer, Longworth). Krause describes the nerve-fibrils of the axis cylinder as ending in free bulbous extremities between the cells.

(*b*) *Cylindrical End-bulbs* (Krause).—These are found in the conjunctiva of the calf. They are longitudinally striated bodies, consisting of a connective-tissue capsule with oval nuclei. A medullated nerve-fibre enters at one extremity of the bulb and its axis cylinder traverses the interior in a longitudinal direction, ending near the opposite end of the body in a pear-shaped enlargement or a straight extremity. The medullary sheath of the nerve-fibre disappears at its point of entrance into the body. The sheaths of Henle and Schwann become continuous with the capsule. The interior of the bulb is occupied by a longitudinally striated substance (internal bulb of Krause), which is made up of a number of flat and closely stratified connective-tissue cells forming a sheath for the terminal end of the axis cylinder. In the clitoris these end-bulbs (genital end-bulbs) have the same general structure; they are round, elongated, or oval. They may have one or more medullated nerve-fibres, a capsule, and internal bulb of finely granular substance, with shining nuclei and refracting fibrils seemingly from the afferent axis cylinder.

Pacinian Corpuscles (Vater's corpuscles). These are elliptical, concentrically striated bodies found distributed in the course of the digital nerves, in the palm of the hand and in the sole of the foot. They occur occasionally in the head of the pancreas, on the dorsum of the penis and clitoris, in the coccygeal region, among the nerves of the mammary gland, and in the sheath of the tendons of the forearm. They are also seen in the mesentery of the cat.

In man and mammalia they are 1 to 2 mm. in their long diameter, and 0.7 to 1.2 mm. broad, being smaller in the young than in the adult. They appear to consist of a series of concentric capsules surrounding an elongated cavity (central mass), which is seen to be filled with granular matter indistinctly longitudinally striated. A medullated nerve-fibre with a thick lamellar sheath enters the corpuscle at one extremity, the axis cylinder traverses the central part of the interior and ends at the opposite end in a blunt expansion, or may break up into a cluster of terminal fibrils. The medullary sheath disappears after the entrance of the nerve-fibre into the body, while the lamellar sheath of the nerve supplying the corpuscle becomes continuous with the capsules of the same.

These capsules are thinner in the periphery than in the central part of the corpuscle. They are made up of delicately fibrillated connective tissue, between whose fibres exists an amorphous substance. These fibres of connective tissue are arranged both longitudinally and circularly in each capsule, the former predominating in the more central capsules. The capsules are lined with endothelial cells, the nuclei of which are prominent toward the central mass. The central mass consists of a granular substance, concentrically striated in its long axis, and containing nuclei. The axis cylinder in the centre is deprived of medullary sheath, but still shows distinct dark borders, being probably covered by the sheath of Schwann. The axis cylinder may finally divide into a number of terminal fibrils, which have bulbous extremities and are distinctly fibrillated. Blood-vessels enter with the nerve-fibre, and are principally distributed to the external region of the corpuscle between the capsules, though plexuses are found internally also.

Some nerve-fibres may simply traverse one or more Pacinian corpuscles, and without terminating in these may finally do so in a third.

CHEMISTRY OF NERVE-TISSUE.—1. *Albuminous Substances.* Albumen exists especially in the axis cylinders and the substance of the ganglion-cell. Part of it resembles in properties the myosin of muscle-fibre. Dilute salt solution will also isolate an albuminous substance from nerve-tissue, which is precipitated by strong salt solution or water. In addition to the above we find potash albuminate and a globulin substance. In the gray substance we meet the albuminoids, nuclein, and a keratin-like substance containing sulphur, first described fully by Kühne and Ewald, called neurokeratin. This exists in the medullary sheath of nerve-fibre. The sheath of Schwann resembles elastin, but does not yield gelatin. The connective tissue of nerve-tissue yields gelatin.

2. *Fats* soluble in ether, and substances resembling fats, found especially in the medullary sheath: Cerebrin, lecithin, protagon (Liebreich), this substance is a compound of lecithin and cerebrin, and exists chiefly in the cerebrum.

3. *Water Extractives*, xanthin, hypoxanthin, kreatin, inosit, lactic acid, leucin, urea (in retention of urine).

QUANTITATIVE.	Per cent.
Water, gray substance	81.6
" white substance	64.4
Albumen, gray substance	55.4
" white substance	27.7
Lecithin $C_{44}H_{90}NPO_9$, gray substance	17.2
" " " white substance	27.7

Quantitative.	Per cent.
Cholesterin and fat, gray substance	18.7
" " white substance	51.9
Cerebrin, gray substance	0.5
" white substance	9.5
Ether extractives, gray substance	6.7
" " white substance	3.3
Salts, gray substance	1.5
" white substance	0.6

The gray substance contains more phosphoric acid (Landois).

In addition to the above we have kephalins and myelins described by Thudichum; they are phosphorized principles soluble in water, kephalin more so than myelin. The salts above mentioned include sodium, potassium, and magnesium phosphate, potassium chloride, sodium carbonate, and potassic sulphate.

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Henry Koplik.

NERVI. The town of Nervi stands upon a narrow, shelf-like plateau which intervenes between the base of an outlying spur or side range of the Apennines and the shore of the Mediterranean Sea, at a point some six miles distant from Genoa, in a southeasterly direction. The general trend of the coast-line along what is known as the Riviera di Levante, or Eastern Riviera, between Genoa and Spezia, is from northwest to southeast; but, as in the case of the Western Riviera, the regularity of the line is frequently interrupted by the occurrence of bays, which are guarded by rocky headlands, jutting into the sea from the main chain of the Apennines, just as similar headlands along the Western Riviera reach down to the sea from the Maritime Alps. The scenery along this coast is consequently very similar to that of the Western Riviera, and, as the writer can testify from personal experience, it is exceedingly picturesque and beautiful. The width of the little plateau upon which Nervi is built does not exceed a quarter of a mile; its elevation above sea-level is very inconsiderable, and probably does not exceed one hundred feet. The shore-line at Nervi runs nearly due east and west; the spur or side-chain of the Apennines already mentioned, consisting of three separate mountain peaks, extends parallel with the shore, immediately back of the town. The most westerly and terminal peak of this side-range is only about seven hundred or eight hundred feet high, and it is covered to its top with a growth of olive-trees; the other two peaks are much higher (about twenty-five hundred feet), and their summits consist of bare rock.

The town of Nervi has a population of about eight thousand, and it is built, in the straggling fashion so familiar to travellers who have visited the Italian coasts, along the old Genoa and Spezia post-road. At this point the road does not skirt the shore, but hugs the base of the hills, so that the town stands close under the shelter of their steep slope, and is effectually protected from northerly winds. From easterly winds it is, in common with all points along the Eastern Riviera, protected in great measure by the main chain of the Apennines. The northeast wind is not effectually kept out, but gains access through gaps in the hills, and is sometimes strongly felt at Nervi. "The northwest wind," says Dr. Sparks, "is also not unknown, and Dr. Thilenius says of it, 'The most dangerous wind, and the wind which is always the most violent, is the cold, cutting, dry, and bitter northwest.'" The warm, damp, relaxing "scirocco" wind, blowing from the southeast, is also of frequent occurrence.

The rainfall at Nervi is heavier than along the Western Riviera. The average fall in each of the six colder months of the year, derived from seven years of observation, is quoted by Dr. Sparks from Dr. Thilenius as follows: November, 6 inches; December, 4.88 inches; January, 4.78 inches; February, 3.23 inches; March, 1.19 inches; April, 2.20 inches. In the winter of 1876–77 the number of rainy days, including days on which slight showers occurred, during the months of December, January, February, and March was 48. At Mentone, during the same period, 27 such days occurred (Sparks). This season is spoken of by Dr. Sparks as a comparatively dry one. The winter of 1874–75, on the other hand, appears to have been at Nervi an exceptionally wet one, for Dr. Sparks quotes Dr. Thilenius to the effect that during that season "it rained almost incessantly for three months, day and night, and the air was so saturated with moisture that there was scarcely any difference between the wet- and dry-bulb thermometers." In the comparatively dry seasons of 1875–76 and 1876–77 the mean relative humidity, measured by August's psychrometer, and quoted by Dr. Sparks from Dr. H. J. Thomas, of Baden-Weiler, was as follows:

	Dec.	Jan.	Feb.	March.	April.
1875–76	64.0	60.0	61.8	66.7	72.7
1876–77	75.0	63.2	61.4	68.5	....

Dr. Kisch[3] gives the mean relative humidity of Nervi as 62.9 to 66.6 per cent. So far as these figures go, they appear to indicate greater dryness of the atmosphere at Nervi than exists at Mentone, yet Drs. Weber[2] and Sparks[1] both pronounce the climate of Nervi to be moister than that of Mentone.

At Genoa, which, it will be remembered, is only six miles distant, the mean relative humidity is decidedly less than it is at Mentone, and during the prevalence of northerly winds it falls very low indeed, below twenty per cent.; occasionally as low as eight or nine per cent. On the other hand, when the "scirocco" blows, the air at Genoa becomes very moist. Dr. Hann, in his "Handbuch der Klimatologie," gives the mean relative humidity of Genoa, for the five months November to March, as fifty-seven per cent. Now the free exposure of Nervi to the moisture-laden southerly winds and its shelter against the cold, drying, northerly winds characteristic of the Genoa climate, would no doubt combine to effect a great modification of the mean of humidity at the former place when compared with that of the latter; a modification, namely, in the direction of a higher percentage of saturation. Yet, taking into account the close proximity of Nervi to Genoa, and the relative humidity *figures* for Nervi given in Dr. Sparks's book, it seems not impossible that this writer and Dr. Weber, in pronouncing the Nervi winter climate moister than that of Mentone, have confounded the two factors of rainfall and humidity. The rainfall of Genoa is far greater than it is along the Western Riviera; the mean relative humidity is, on the other hand, very considerably less; and no better example than this feature of the Genoa climate can be adduced in support of what has already been said in the article on Climate, viz., that "The humidity of the atmosphere can by no means be measured by the amount of the rainfall." Probably the variations in the atmospheric humidity at Nervi are much greater in amount and more frequent in occurrence than they are at Mentone. "In spite of its raininess," says Dr. Sparks, "the soil of Nervi—clay-slate—is favorable to its rapid drying."

As to the winter temperature of Nervi, it appears to be about the same as that of Mentone. Dr. Kisch[3] tells us that the temperature of the two places is similar in respect to its mean and to its variations. The observations of General Brocchi, during the years 1849–1864, give the mean temperatures of November and December for thirteen years, and those of January, February, March, and April for fourteen years; they are quoted by Dr. Sparks[1]

as follows: November, 55.31°; December, 47.84°; January, 46.36°; February, 47.8°; March, 49.0°; April, 58.1°.

The absolute reliability of these figures is not vouched for by Dr. Sparks, as he explains that he "knows nothing of the arrangement of the instruments or hours of reading."

The following table, showing a comparison of the Nervi and Mentone temperatures for a single winter, is quoted from Dr. Sparks's book, its figures being derived from calculations by Dr. Sparks, based upon observations published by Herr Schulze, in his work on the health-resorts of the Riviera, and of Middle and Lower Italy.[4]

TEMPERATURES AT NERVI AND AT MENTONE, WINTER OF 1874–75. (Sparks.)

	Nov.	Dec.	Jan.	Feb.	March.
Mean temp. at 8 A.M.					
Nervi	56.0	52.0	51.0	44.0	49.0
Mentone	54.0	48.2	50.5	44.5	49.8
Mean temp. at 2 P.M.					
Nervi	59.5	56.5	58.0	50.3	55.4
Mentone	59.2	53.6	56.0	49.0	57.5
Maximum temp.					
Nervi	70.5	66.0	66.0	61.0	64.0
Mentone	70.5	64.0	64.0	55.0	66.0
Minimum temp.					
Nervi	44.0	41.0	44.0	36.0	44.0
Mentone	46.0	42.0	46.0	36.0	48.0

The following data for mean temperature at 8 P.M. and for absolute minimum temperature at Nervi, during the months of December, 1876, and January, February, and March, 1877, are quoted by Dr. Sparks from an article by Dr. H. J. Thomas in the *Berliner klinischer Wochenschrift*. The figures for the mean temperature are as follows: December, 51.5°; January, 49.3°; February, 47.2°; March, 47.4°. The minimum temperature observed was 35.2° on March 2, 1877. It is worthy of note, in connection with this last-quoted figure, that a minimum temperature of 25.5° was recorded in the "West Bay" of Mentone during this same month. Moreover, judging from a table of monthly highest and lowest temperatures at Mentone which is given by Dr. Sparks in his account of that place, it would appear that this winter season of 1876–77 was not an unusually warm one on the Western Riviera, and that March, 1877, was exceptionally cold; and it is reasonable to infer that such was also the case along the Eastern Riviera. If such was the case, and if Dr. Thomas's observations were made under like conditions with those of Messrs. Freeman and Andrews at Mentone, the greater mildness, or, at least, the greater equability of the Nervi as compared with the Mentone climate would be illustrated, although not accurately measured, by these two figures alone.

On the other hand, Dr. Thomas's 8 P.M. figures, when compared with the daily mean figures of Dr. Brocchi, already quoted, show a decided discrepancy between the two sets of observations, especially if we assume, on the authority of the Mentone figures, that at Nervi the winter of 1876-77 was no warmer than the average.

It is to be regretted that no fuller, more extended, and more accurate observations respecting the various climatic factors of the place have as yet been made and recorded at Nervi. Nevertheless, so far as temperature is concerned, the climate is undoubtedly a mild one, and almost identical in this respect with that of the Western Riviera. As remarked by Dr. Sparks, "In spite of the want of really scientific observations on the climate of Nervi, there is no doubt of the mildness of its climate. The abundant subtropical vegetation, and the growth of standard lemon-trees, is a proof of this." The following quotation from an article by Dr. Edward Haughton (*London Lancet*, December 13, 1884) is interesting as illustrating the agency of mountain shelter in the production of Nervi's mild winter temperature. In February, 1884, this gentleman visited Genoa, Pegli, and Nervi, all on the same day, for the express purpose of making observations on this point. "The result," as he tells us, "was that the wind, which was bitterly cold at Genoa, was much milder at Pegli, especially in the valley behind the town, whilst it was perfectly calm, and even warm at Nervi, so long as the headlands which protect the place were not rounded by the visitor." This same point is further exemplified in a striking manner, although on a small scale, in what Dr. Sparks tells us concerning a sheltered coast-walk at Nervi itself; and everywhere along this part of the Italian coast we find that shelter from cold wind and exposure to the sun combine in varying degrees to cause marked elevation of temperature, even "in the dead of winter." At Nervi the railway runs between the town and the sea. "Below the railway, and just before the rocky shore takes its deep descent into the sea, a path a few feet wide has been cut along the edge of the rock for the use of the coastguardsmen, and as it accurately follows the indentations of the coast-line, and is absolutely protected from the north by high garden-walls, or by part of the rocky slope, or the railway embankment, while it gets all the southern sun in its full force, it is naturally an excellent promenade for invalids. Here they can walk or sit, or, if they choose, at certain points descend close to the sea, and enjoy a temperature of 64° to 68° Fahr., while in the High-street of Nervi the thermometer at the same time is not higher than 43° or 44°. Naturally great care is necessary to be provided with plenty of wraps to put on when returning from the shore to the town."

Of amusements for the invalid there appears to be a great dearth at Nervi, and the facilities for the making of excursions in the immediate neighborhood are exceedingly limited. "The neighbourhood of Nervi," says Dr. Sparks, "offers but a limited field for excursions owing to the nearness and steepness of the high hills at the back of the town. There is no drive along the shore close to Nervi, though further west the road at some places nearly overhangs the sea. . . . For amusements of all kinds, except rod-fishing, Nervi presents little opportunity."

According to the testimony of Drs. Sparks and Kisch, the hotel accommodations are good, but "villas and sets of rooms in flats are difficult to find."[1] Dr. Sparks, however, writing in 1879, tells us that complaints had been made concerning the quality of the drinking-water of the town. Nervi appears to be chiefly popular among the German visitors to this region, and Dr. Sparks remarks that it is "rather a German than an English colony."

Concerning the class of invalids who should be recommended or permitted to pass a winter at Nervi, it is impossible to decide with any degree of precision until a longer and more thorough series of meteorological observations shall have given us a more accurate knowledge of the local climatic peculiarities. For the present it can only be said that the general features of the climate are those of the Italian Riviera, and that the local modifications are such as to render the climate less exciting than that of the Western Riviera resorts (see articles, Riviera and Mentone). *Huntington Richards.*

[1] The Riviera, by Edward J. Sparks, M.A., B.M., Oxon.
[2] Ziemssen's Handbuch der Allg. Therapie und Klimatotherapie.
[3] Eulenburg's Real-Encyclopädie, art. Nervi.
[4] Die Klimatischen Curorte der Riviera, Mittel- und Unter-Italiens.

NEUENAHR is situated in Prussia, between Cologne and Coblenz. There are here a number of artesian wells, giving an alkaline water of somewhat elevated temperature, which has acquired considerable popularity in recent years. The five springs are known as the Augustaquelle, Victoriaquelle, Kleiner Sprudel, Grosser Sprudel, and Marien Sprudel. The following is the composition of the Grosser Sprudel, according to the analysis of Mohr. Each litre contains of:

	Grammes.
Sodium bicarbonate	1.055
Ferrous bicarbonate	0.010
Magnesium bicarbonate	0.450
Calcium bicarbonate	0.305
Sodium sulphate	0.250
Sodium chloride	0.150
Calcium chloride	0.040
Lithium chloride	0.003
Silicic acid	0.050
Total solids	2.313

There is some free carbonic acid. The temperature of the different wells ranges from 68° F. (Kleiner Sprudel) to 104° F. (Grosser Sprudel).

The waters of Neuenahr, which are very like those of Ems and Vichy, are employed in baths and douches, and are also taken internally. The dose is from two to eight glasses, taken at intervals of fifteen minutes, alternating with moderate exercise in the open air or, if the weather forbid, in the Trinkhalle.

The spa is frequented by sufferers from chronic catarrhal affections of the respiratory, urinary, and digestive organs, diabetes, old pleuritic exudations, gout, ague cake, certain forms of dyspepsia, and abdominal plethora. A course of treatment occupies from three weeks to a month, and the season extends from the first of May to the middle of October. The accommodations at Neuenahr are reported to be very good. Opportunities are afforded visitors for taking the so-called milk-, whey-, and grape-cures. The climate is mild, and the place is well protected from high winds. *T. L. S.*

NEUHAUS, in Austria, is a thermal station not far from Vienna, lying at an elevation of about 1,200 feet above the sea. The climate is mild. The waters are very poor in mineral constituents, containing only about 0.3 Gm., chiefly calcium carbonate, per litre; they are seldom taken internally, but are employed in the form of baths. The temperature of the springs is about 95° F. Neuhaus enjoys some reputation in the treatment of gout and rheumatism, and is popular with those suffering from debility or nervous prostration. The season lasts from the first of May to October. *T. L. S.*

NEUHAUS, in Bavaria, is a rather popular spa, in the town of the same name, situated at an elevation of about 730 feet above the sea-level. It has four mineral springs, called respectively the Bonifacius-, Elisabeth-, Hermanns-, and Marienquelle. The town lies not far from Kissingen, and the waters resemble those of the latter place, and are used to fulfil the same indications. *T. L. S.*

NEURALGIA. Definition and Nature.—Neuralgia is the name given to a number of painful affections owing their origin, at least in part, to a disordered action, or neurosis, of the sensory nervous system.

Those varieties of pain, the character, situation, severity, and duration of which are wholly determined by processes acting on healthy sensory nerves, and from without, are not called neuralgic. Irritations of the sensory nerves may, however, act as the cause, *sine quâ non*, of neuralgic attacks, and if long continued may even induce the neuralgic condition of the nervous centres.

Probably the majority of the neuralgias are, in fact, due in part only to any primary or essential neurosal disorder of the nervous centres, and indicate in addition some irritation of the sensory nerves from without.

This is eminently true of most of the typical neuralgias of the superficial nerves; their gradual onset and decline, and protracted course, and the limitation of the pain to the distribution of one or more peripheral nerves pointing to some localized irritative process (frequently a neuritis) acting on the affected nerve, or corresponding portions of the nerve-centre.

Anything which causes an abnormal irritability of the sensitive nerves, or an instability of the nerve-centres, such as an inherited neuropathic tendency, exhaustion, anæmia, or either one of many animal or mineral poisons, will increase the morbid influence of these localized irritations from without.

It is uncertain whether there are special nerves and nerve-centres intended for the conveyance and perception of painful impressions, but the results of experimentation, and the difference in the behavior in disease of this function—if so it may be called—from the other sensory functions, leads to the belief that such may be the case.

Again, it may be that the nerves of pain are the same with the nerves for the general feelings (Gemeingefühle) of satisfaction or discomfort, which accompany, and yet are distinct from, the special sensations of relation, such as touch, temperature, and the like.

If there are special nerves and nerve-centres for pain, it is probable that they are the seat of the disease in neuralgia.

It is common to hear the neuralgias of the superficial nerves spoken of as the only affections really deserving the name, and as belonging in a different category from the visceralgias and the periodical headaches, as well as from the pains of intermittent recurrence, but of ill-defined seat, to which children and feebly-nourished persons, and especially neurotic persons, are liable.

In so far, however, as these painful disorders occur under similar conditions with typical neuralgias of the superficial nerves, and are themselves of unknown origin, there is much gained in treating of them both as kindred affections, and contrasting them with each other.

General Etiology and Pathology.—An *inherited neuropathic tendency* is the most important cause of neuralgia, and it is often impossible, in a given case, to measure the degree to which its influence is felt. It is, however, a far more important element in the migraines and the visceralgias than in the superficial neuralgias, and among the latter its effect is most strongly felt in the neuralgias of the fifth pair, and of the intercostal nerves.

The exact pathological state of the nervous centres in neuralgia is not known, any more than it is in the case of the other neuroses. Some of the conditions that give rise to it are, however, better understood.

Chief among these are: *Anæmia*, which acts both by impoverishment of the blood, and by overcharging the blood with carbonic acid; the *presence of abnormal substances in the blood*, as in gout, diabetes, malaria, chronic nephritis, and metallic poisoning; *absorption of the products of imperfect digestion or metabolism; the impairment of the vascular tonicity*, as in fatigue; *peripheral irritations*, such as disease of the teeth, eyes, respiratory and digestive tracts, uterus, and ovaries; chronic inflammation of the nerve-sheath; *localized anæmia or congestion of nerves or nerve-centres.*

Anæmia and states of *nervous debility* or *chronic fatigue* are common underlying causes of neuralgia, even though not the whole cause, and it is almost always best to suspect them and to fortify the patient against them by ample nourishment and tonic treatment. Although anæmic and debilitated patients are more prone than healthy persons to neuralgias of every sort, this is especially true with regard to the superficial neuralgias, the sufferers from migraine and the visceralgias being often in good, even robust, health so far as any anæmic tendency is concerned.

Anæmic neuralgias are, as a rule, protracted, like their cause, but may in the end pass away rapidly under appropriate treatment.

Diabetes sometimes causes intractable and often symmetrical neuralgias, especially sciatica, even though the symptoms of the underlying disease are not marked.

Gout and kindred disorders (lithæmia) may cause neuralgia, partly by alteration of the blood, or by direct irritation of the nervous centres, and partly by inducing neuritis. These neuralgias are sometimes bilateral and fugitive, sometimes lasting, according to their origin. Visceralgias are also common in the gouty, but it is an open question whether this may not be, in part, because of the neuropathic tendency which is intimately connected with gout.

Chronic nephritis, and the vascular and nutritive disorders associated with it, may cause various neuralgias, both superficial and visceral.

Syphilis likewise causes neuralgias both in its early and its late stages, and here also the manner of its action may be either direct or indirect. It is also worthy of reflection, in a given case of this kind, whether the cause of the neuralgia may not be the antisyphilitic treatment which has been used, and not the disease itself.

The neuralgias due to *mineral poisoning* are apt to be bilateral, or to attack different parts successively. The arthralgias and visceralgias of lead-poisoning belong in

this category, but will be treated of with the other symptoms of the same origin.

Peripheral irritations cause neuralgia which is sometimes confined to the region irritated, sometimes located in distant parts, and are always to be carefully sought for and eliminated, since, even when they constitute only partial causes, they may be practically responsible for the seizures. Carious teeth may excite neuralgia in other branches of the fifth pair besides that directly irritated.

Injuries, such as *severe jars*, as in railroad accidents, or *blows*, even when they do not apparently injure any particular nerve, may excite severe neuralgias, and the same is true of *emotional excitement or mental overstrain, acute or chronic*.

The pains due to the pressure of *cancerous growths*, or other *tumors*, and *aneurisms*, though often classed as non-neuralgic, are really not always to be distinguished from neuralgia by any intrinsic characteristic. The diagnosis is often established by other indications of the presence of morbid growths, and, so far as the nervous system is concerned, is rendered probable by unusual persistence and severity of the pain, the occurrence of signs of neuritis, such as marked atrophy, contracture, anæsthesia, etc. A *bilateral distribution* of the pain is also suggestive of such a cause, pointing either to pressure upon symmetrical nerve-trunks at their exit from the spinal canal, or, in the case of the brachial nerves, to a symmetrical enlargement of lymphatic glands. Neuralgia of the fifth pair has occasionally been traced to aneurism of the internal carotid.

The connection between the superficial neuralgias and neuritis is particularly intimate, and calls for special consideration. The gradual onset and decline of most of these neuralgias, such as sciatica, their protracted course, the limitation of the pain to the tract and distribution of single nerves, and the fact that the pain is apt to be rather remittent than intermittent, has led some observers to consider that the neuralgia is really secondary to neuritis.

Again, even when the attack begins apparently as a simple neuralgia, a neuritis is often developed later, as shown by such signs as tenderness along the nerve, persistent alterations of the sensibility of the skin, and even muscular atrophy and trophic changes in the skin, periosteum, etc.; and under such circumstances the neuritis may at least play an important, though secondary, part in the production of the symptoms. Even where a neuritis cannot be proved, and where the pain is typically intermittent, it is never safe to assume its absence in a superficial neuralgia of long standing.

The pain felt under these circumstances is not to be regarded simply as a symptom of the neuritis. It may disappear while the neuritis remains, and is, in fact, an induced neuralgia.

Cold and damp weather and the atmospheric changes preceding and accompanying storms are fruitful causes of neuralgic attacks, acting no doubt in part by depressing the general nervous tone, and in part by causing congestion or anæmia of the sensitive cutaneous nerve-fibres, and even increasing any neuritis that may be present.

It is proper to speak here of the relation to neuralgia of such general influences as *age* and *sex*.

Childhood is usually considered nearly free from neuralgia, but this is only true of the typical, peripheral neuralgias of protracted course. The so-called "growing-pains" of childhood may fairly be called neuralgic, and children suffer from visceral neuralgias, and sometimes from typical migraine or periodical headache.

Puberty brings an increased tendency to migraine and headache, which then usually lasts until the age of forty-five or fifty. The neuralgias of acute anæmia and chlorosis occur also largely at this period, though anæmia is probably also a cause of some of the pains of childhood.

All neuralgias are most common in *middle life*, mainly because it is then that the nervous strains incident upon increased cares and exposures of all kinds make themselves most strongly felt, and act both directly and indirectly by increasing neuropathic tendencies.

Neuralgias *rarely begin in old age*, and when they do they are very intractable, perhaps because they depend upon tissue-degenerations in the nervous and vascular systems. It is, however, a noticeable fact to which the writer can bear testimony, that, in spite of their severity and persistency, the neuralgias of old age sometimes unexpectedly disappear for longer or shorter periods, or even permanently.

The *female sex* shows a relatively great liability to the neuralgias of neuropathic origin; the *male sex* to neuralgias of peripheral origin.

General Symptomatology.—All neuralgias have in common a greater or less tendency to *periodic* and apparently spontaneous *recurrence*, but the degree to which this periodicity is seen varies greatly.

The most regular and spontaneous periodicity is met with in the malarial neuralgias and in those of mainly neurosal origin, especially migraine and the periodic headaches. The visceralgias recur less regularly, but their outbreaks also are frequently, to all appearance, spontaneous, that is, due to cyclic changes within the nervous centres themselves, and not to irritation from without. In both cases this tendency to cyclic outbreaks may be interrupted, and attacks precipitated, by various causes.

One variety of the neuralgias of the ophthalmic branch of the fifth pair of cranial nerves shows a marked tendency to daily recurrence at the same hour for a certain period (usually about nine o'clock A.M.), and this is true not only in cases of malarial infection, but where the neuralgia is apparently due to the irritation from catarrh of the frontal sinuses.

Besides these neuralgias of regular recurrence, persons of neuropathic constitution are often liable in some degree to spontaneous attacks of pain, of relatively short duration; but the typical superficial neuralgias of protracted course, as a rule, show but little of this tendency to periodical and spontaneous recurrence, so characteristic of the more distinctly neurosal neuralgias. They may recur, it is true, but this is either from a recurrence of their underlying cause, or because the neuritis, which is usually present as an important complication, if not a cause, does not entirely pass away and excites the neuralgia to fresh outbreak.

Almost all neuralgias have in common a tendency to excite *vaso-motor* and *trophic changes*. The *vaso motor* phenomena are most marked in cases of the migraines, which are often characterized by a marked pallor or redness, or both in turn, of one side of the head. These vascular changes have, in fact, been widely believed to be the essential feature of migraine, and to be directly responsible for the pain; but this is, in the writer's judgment, a mistaken opinion. Similar symptoms are seen in the other neuralgias, especially those of the neighborhood of the eye, and probably attend, if they do not cause, the changes in the glandular secretions (tears, urine, mucus, gastro-intestinal fluids), which are also very common near the seat of any severe neuralgia, and even at a distance from it. The writer has seen a sharp attack of intercostal neuralgia, for instance, of short duration and due to acute fatigue and exposure, pass entirely away with a copious discharge of limpid urine, such as often attends the close of a migrainoid attack. Finally, migraine is often unattended by any noticeable vascular changes.

The *trophic* phenomena are most marked in the case of the superficial neuralgias, and range from such changes as are obviously due to neuritis (herpes zoster and other cutaneous eruptions, muscular atrophy, and the like), to the more temporary alterations which are partly of vaso-motor origin, or due to irritation of trophic or glandular nerves, and partly of unknown origin (œdema of the skin, changes of color and increased brittleness of the hair, temporary muscular enfeeblement, impairment of the eyesight, possibly even glaucoma, etc.). The trophic changes in migraine are but slight.

It is often included in the definition of neuralgia, that the pain is confined to the *region of distribution of one or more nerve-branches*, but this applies only to the neuralgias of the superficial nerves.

It is common to most neuralgic attacks that the pain is *intermittent or remittent* in severity. When a continuous dull aching is present, it may be suspected that the neuralgia is complicated by a material degree of neuritis.

For further examination of their symptomatology, neuralgias may be divided into :

1. Superficial neuralgias.
2. Migraine and the periodical headaches.
3. Visceralgias.
4. Unclassified neuralgias of irregular distribution.

1. The *superficial neuralgias* are limited to the course and areas of distribution of one or more nerves or parts of nerves supplying the skin and adjacent structures.

The principal varieties are : 1, The neuralgia of the fifth nerve, of which there are several subdivisions ; 2, the neuralgia of the occipital nerve ; 3, the neuralgia of the cervico-brachial nerves ; 4, the neuralgia of the abdominal nerves ; 5, the neuralgia of the anterior crural nerves ; 6, the neuralgia of the sciatic nerves.

All these neuralgias have the following peculiarities in common : The attacks are sometimes brief, oftener of relatively long duration.

The *brief attacks* generally occur in persons of neuralgic habit, and under these circumstances are more likely to attack the facial, intercostal, or abdominal nerves than the brachial or the sciatic. They may occur spontaneously, or from some special cause, as fatigue, excitement, or exposure, and may pass away after a night's sleep, like an attack of migraine, the disappearance being sometimes attended with a copious secretion of urine. Gouty persons are also subject to brief neuralgic attacks ; and there are other obscure disorders of the nutrition (so-called lithæmia, and the like), of which the same is true, though it is by no means easy to say whether the neuralgia is really secondary to the nutritive disorder, or both are symptoms of an underlying nervous affection. Vaso-motor changes are common in acute attacks of brief duration, leading to pallor or redness of the skin. Such attacks are often attended also by increase, preceded at times by diminution, in the secretion of neighboring glandular organs, and, occasionally, by œdema of the skin. These phenomena are, perhaps, of vaso-motor origin. Hyperæsthesia of the skin is often present.

The *attacks of relatively long duration* usually come on gradually, and are recovered from gradually. The pain is not felt over the whole area of distribution of the nerve, but has its points of election, and from these points the pain spreads or darts further. Sometimes, and especially in the case of sciatica, the course of the nerve itself is the painful region, and it is believed that it is the sensitive nervi nervorum ramifying in the main nerve-trunk that are mainly or even alone concerned in the neuralgic process in such cases. General tenderness along the nerve points to neuritis, but the localized tenderness which has just been referred to, and which is confined to certain definite spots (*points douloureux* of Valleix), probably do not necessarily have this significance. These spots of tenderness are apt to coincide with the foci of pain, but do not always do so. They are usually found where the nerve emerges from a bony or fibrous canal, or where it begins to ramify in the skin. The pain is often accompanied by subjective and objective *disorders of the sensibility*. The former consist in sensations of prickling and numbness, or of heat or coldness.

These sensations often precede or follow as well as attend an attack. When they overlast the attack a long time, and especially if they are sharply localized, they usually indicate that the nerve has been the seat of the inflammation. The *objective* disorders are of the nature either of hyperæsthesia or anæsthesia. The former is usually seen at the beginning or at the height of an attack, and the latter usually later. A persistent impairment of sensibility points to destruction of some of the sensitive nerve-fibres from neuritis.

Trophic changes in the skin and its appendages, or in the muscles, are common and usually point to neuritis. The muscles near an acutely painful region are sometimes temporarily paralyzed without apparent cause. The hair of the eyebrow and scalp has been known to become blanched during a neuralgic attack of the fifth nerve, recovering its color later. This change of color is probably due to the penetration of air into the hair-shafts.

Treatment of Superficial Neuralgias : *vide* also sections on Neuralgia of the Fifth Pair, Sciatica, etc.

Causal Treatment.—The importance of removing the causes of the neuralgia is evident to everyone, but it is not equally recognized that it is necessary to remove partial causes, no matter how many there may be. Such causes are principally : 1, Exposure to alterations of temperature and weather, to be met by suitable clothing, change of occupation, temporary removal to a drier, or, it may be, to a more relaxing climate ; 2, peripheral irritations, either near or remote from the seat of pain ; 3, neuritis, primary or induced (*vide* below under Electricity and Surgical Operations) ; 4, dyscrasias, such as gout, syphilis, diabetes ; 5, fatigue, anæmia, lack of proper nourishment. It should be remembered in this connection that a state of health sufficient for ordinary purposes may not be sufficient as counteractive of neuralgia. What would seem excessive nourishment (see under Neurasthenia), combined, if necessary, with massage and rest and cod-liver oil, arsenic, and large doses of iron, if well borne, is useful in a large number of cases.

Symptomatic Treatment.—This comprises the means used to relieve pain and to counteract the neuralgic condition and the irritability of the nervous centres. The important remedies of this class are : Quinine, aconitine, phosphorus (*vide* under Neuralgias of the Fifth Pair), salicylate of soda, valerianate of zinc, belladonna, opium, croton-chloral, cannabis indica, electricity, hydropathic treatment, counter-irritation, vibration and local manipulation in the affected region, and surgical operations. The method of use of these remedies is too familiar to need comment, except that of the last five.

Electricity is mainly useful in the form of galvanism, which is usually applied with one pole of the battery near the nerve-centres, and the other near the nerve-trunks of the affected part. Its special indications are for the temporary relief of pain and in the treatment of neuritis. It is probably indifferent which pole is used in the painful area, but, on the other hand, it is of great importance, in acute neuralgias, that the current should flow without interruptions and that the strength should not be suddenly increased or diminished. The electrodes should be large, and well nourished with warm water. The strength of the current should not be so great as to irritate the skin, and thereby excite, instead of soothe, the patient. Moderate variations of the current-strength, as made by sliding the electrodes slowly over the skin, sometimes increase the effect. In chronic cases strong currents are sometimes useful, and it is not necessary to observe the same caution as to interruptions of the circuit.

Adamkiewicz has devised an ingenious method of using electricity so as to cause a diffusion of chloroform into the skin ("Die Diffusions Elektrode," *Neurolog. C. Bl.*, 1886, No. 10). A hollow electrode, connected with the positive pole, is filled with a small quantity of chloroform, and the end covered with cotton, which has been moistened, and then dried enough to remove the water from the meshes of the cotton. The current is made to pass through the chloroform before entering the skin, and it has been shown by experiment that the chloroform is carried much more deeply into the skin than when simply applied to the surface. It causes at first an intense burning, but very soon exerts a markedly anæsthetic action, and relieves pain. The current-strength employed is three to five milliampères.

Hydropathic (or *Thermic*) *Applications* (so far as they can be used outside of special institutions) consist in the use of the local and prolonged wet-pack (*vide* under Sciatica) ; local bathing and showering, or, in chronic cases, the filiform douche ; prolonged general warm baths (useful as a general sedative) ; prolonged application of ice (*vide* under Sciatica) ; or the application of dry warmth in the form of hot sand- or salt-bags.

Counter-irritation may be applied in the form of stimu-

lating liniments and ointments, mustard, blisters, the actual cautery, or spray of ether, or of chloride of methyl.

The best liniments are those containing aconite and laudanum combined with alcohol and chloroform, or strong solutions of menthol (ʒ j. to f ʒ j.). A strong aconitine ointment (one part to eight) is said (Webber) to be useful, but must be employed with great caution. These agents act not only by the irritation which they set up, but probably by lessening the sensitiveness of the skin as well. In the same way cocaine, instilled into the eye, will sometimes relieve pain in the globe and in the supra-orbital region.

Prolonged and rhythmical vibration or manipulation over an affected nerve, best done by an instrument designed for that purpose (Granville's hammer), is said to be of service, and similarly, some forms of headache can often be relieved by prolonged manipulation or vibrations with the finger-tips.

Surgical Operations comprise acupuncture, deep injections of irritants, such as water, nitrate of silver, chloroform, or osmic acid; the section of nerves (neurotomy) or removal of a portion of the nerve (neurectomy); nerve-stretching; and the ligature of arteries leading to the nerve-centres or nerve-trunks.

Nerve-section and the ligature of arteries are rarely practised, except in the neuralgias of the purely sensitive fifth nerve, and are discussed under that heading.

Nerve-stretching is appropriate for mixed nerves, and has been applied to almost all the superficial nerves of the body, including the intercostals. Its effect is partly to diminish the conducting power of the sensitive fibres, and thereby diminish the irritations reaching the nerve-centres, partly to alter the condition of nutrition in the nerve-trunks, and partly, no doubt, to exert a so-called inhibitory action with regard to the neuralgic condition of the nerve-centres. The operation is not often followed by serious results if done under proper antiseptic precautions, but when large nerves are treated in this way morbid changes are occasionally set up in the spinal cord. This operation has found its greatest sphere of usefulness in Sciatica, to which heading the reader is referred. Even slender nerves will bear a weight of from ten to twenty pounds without parting, but when diseased they may be more friable.

It is not, however, to be supposed that nerve-stretching is an operation to be lightly undertaken.

An examination of the list of mischances from its use is well fitted to inspire caution. Such a list, with an excellent critical examination of the whole subject, has recently been prepared by Dr. Lagrange,[1] who believes that the therapeutic value of the operation consists essentially in its action upon the spinal centres, mainly due to direct traction. If this action goes too far it is capable of setting up acute and chronic inflammations of the spinal nerve-roots, cord, and membranes.

The author regards it also as quite possible that the deep suppurations which sometimes follow the operation, though indicating, no doubt, imperfect antisepsis, imply also an impaired vitality of the tissues due to the operation on the nerve which supplies them. Nerve-stretching by forced position of the limb (in sciatica) is less dangerous than where the nerve is exposed.

Acupuncture of nerves (including galvano-puncture) and the deep injection of irritating solutions, probably act almost exclusively by their indirect influence on the nerve-centres, and do not differ much, except in the degree of the irritation which they set up. They are unquestionably beneficial, sometimes in acute and sometimes in chronic cases, and may be resorted to when the other surgical operations cannot be used; but, on the other hand, they are not free from danger. Alarming results have been known to follow the use of chloroform, probably by its introduction into a vein, though this is a rare event. The best way to avoid it is to introduce the needle, alone, until its point comes close to the nerve, and not to inject the chloroform if any blood appears. The dose is ♏ x. to xx.

Osmic acid (♏ x. to xx. of a one per cent. solution, freshly made) has occasionally given rise to abscess, or to sloughing, where repeated injections have been used in the same neighborhood and close under the skin.

Special Forms of Superficial Neuralgia. Neuralgias of the Fifth Cranial (Trigeminal) Nerve.—These neuralgias may be divided into the *acute* and the *chronic* varieties.

1. The *acute* forms are apt to occur in persons of neuropathic constitution, either as a manifestation of special liability, or induced by some slight irritation in either a neighboring or a distant organ (uterus, stomach); or in alternation with neuralgic pain in some other part of the body, as the abdominal viscera, the whole forming an attack such as is likely to recur with more or less periodicity.

2. The *chronic* trigeminal neuralgias are serious and complicated affections. Though often implying a neuropathic constitution, they are actually brought on, in many cases, by peripheral irritations, or by causes impairing the vitality of the nervous centres or interfering with the circulation in them. In one severe case occurring in a healthy man the attack began immediately after a serious railway concussion, in which the patient was much bruised and shaken, but not injured about the head so far as known.

In other cases it is impossible to trace them to any cause, and in any case, when the neuralgic habit has been fairly established, it becomes practically independent of its origin.

The neuralgia may affect one branch of the trigeminal nerve, or several branches simultaneously. It has also a tendency to spread from one division to another, or from the fifth to the occipital nerves.

The neuralgias of the *first or ophthalmic division* are sometimes of malarial origin, and even when not malarial, are liable to recur in regular daily paroxysms for several weeks, usually attending a catarrhal inflammation of the frontal sinuses. Diseases of the conjunctiva or globe (glaucoma, iritis) are other causes of this form of neuralgia, but it must be borne in mind that if we may judge by the sequence of the symptoms, the glaucoma, and a variety of other structural changes, may be the result of the neuralgia instead of its cause. Similarly, an increased deposit of dentine has been apparently traced to neuralgia of the lower branches of the fifth pair, but the effect may have been mistaken for the cause.

Chronic neuralgia of the *second and third division* of the fifth is in a large proportion of cases excited by carious teeth, ossification of the pulp cavity (said to be especially common in persons of gouty descent) and other affections of the teeth as well as of the alveolar process. These irritations usually set up a neuritis, which has several times been demonstrated on excised nerves, and this neuritis is doubtless capable of keeping up the neuralgia after the original source of irritation has been removed.

The most serious variety of these chronic neuralgias is the so-called *tic douloureux*, or *epileptiform neuralgia*, the chief characteristic of which is the lightning-like onset and disappearance of the paroxysms of pain, its severity, and its obdurate resistance to treatment. This variety constitutes, in fact, the usual type of all the chronic neuralgias of the fifth nerve, no doubt on account of some physiological peculiarity which we cannot more nearly unravel. Unless relieved by treatment these neuralgias often last indefinitely, even throughout the patient's lifetime, though sometimes with long intervals of relief.

The *treatment of the facial neuralgias*, so far as it differs from that of the other superficial neuralgias, is as follows:

For the periodical neuralgias of the ophthalmic branch, even those of non-malarial origin, quinine is pre-eminently useful. It is best given about four hours before the expected attack, in a single dose of ten, fifteen, twenty, or even thirty grains, but should be discontinued as soon as possible.

For the epileptiform neuralgia, or other chronic forms, aconitine, gelsemium, phosphorus, and quinine are often very useful. They should be given at first in small doses, but rapidly increased, under constant observation, to the limit of the patient's endurance. *Aconitine* (the crystallized alkaloid) is best given at first in doses of $\frac{1}{100}$ to $\frac{1}{300}$ grain

every two or three hours, in pill or solution; then, if no unusual susceptibility shows itself, in doses of $\frac{1}{200}$ to $\frac{1}{100}$, or even more, though this dose is rarely passed without the patient's complaining of severe tingling and numbness of the extremities, and sometimes of a sense of coldness and faintness. A *moderate degree* of these symptoms does not contraindicate the continuance of the treatment for some days, or even weeks, if the patient is otherwise in good health, and is constantly under observation. Tincture of aconite root can be substituted if necessary, but is less certain in its action.

Gelsemium may be given in any reliable preparation, until the signs of its physiological action appear, the most characteristic being a drooping of the eyelids.

Phosphorus is best used in the alcoholic solutions, with a little glycerine and spirits of peppermint added (J. Ashburton Thompson), in doses of $\frac{1}{200}$ to $\frac{1}{100}$ grain every three hours, up to $\frac{1}{5}$ to $\frac{1}{4}$ grain daily, but should not be continued more than a few days at a time, and not so long if it causes gastric irritation.

In some cases *surgical operations* on the affected nerve are eminently in place, and, as a rule, the best operation is that which is most radical while consistent with safety. In these days of antiseptic precautions surgical intervention may be called upon more freely than formerly, and a skilful surgeon can carry the division of either of the branches of the fifth nerve back to its exit from the skull without much danger. This may be combined with nerve-stretching, if desired, which perhaps adds a little, though only a little, to the effectiveness of the operation, and also slightly increases its danger. In extreme cases the facial or carotid arteries may be tied, with a view partly to the alterative action on the nerve-centres, partly to removing inflammation of the nerve-trunks.

The *clinical indications for neurectomy* are not precise, and it has proved useful even when there has been no discoverable peripheral irritation or neuritis. The mode of action of neurectomy is probably at least threefold: 1. It exerts an alterative or inhibitory influence on the nerve-centres. 2. It secures a physiological rest for the nerve-centres by removing one main channel through which ordinary excitations reach them. 3. It separates the nerve-centres from the inflamed peripheral extremity, or from sources of peripheral irritation.

Occipital and Cervico-occipital Neuralgia approaches the neuralgias of the fifth nerve in severity and in the tendency to assume the epileptiform type, and often superadds itself to them, especially to the supra-orbital neuralgia, by extension. In its typical form it is commonly unilateral, and this, together with its history and the character of the pain, usually serves to distinguish it from the occipital headaches met with in neurasthenia, chronic nephritis, or intra-cranial disease.

Brachial and Cervico-brachial Neuralgia has the distribution which its name implies, and the characteristics of a typical superficial neuralgia (*vide* above). Like the rest, it is often due to injury or neuritis, the latter being sometimes secondary to affections of the shoulder-joint, but it may occur simply as a sign of debility or of the neuropathic diathesis, or from concussion accidents, and the like.

The pain usually centres in foci, such as the point of the shoulder-blade, the insertion of the deltoid, the neighborhood of the supinator longus muscle, the wrist, and, more rarely, the fingers, and radiates upward or downward from them. The hand and even the whole arm are often the seat of sensations of numbness and tingling, due perhaps to congestion of the nerve or disorders of the circulation of vaso-motor origin, and these sensations sometimes substitute themselves for the neuralgic pain. The *pathological diagnosis* should take into account the possible presence of cancerous cervical glands, pachymeningitis cervicalis (bilateral pain, muscular atrophy, rigidity of the neck), or angina pectoris. The *treatment* is that of the other superficial neuralgias (*vide* above). Surgical treatment by nerve-stretching is possible at any point, even as high as the cervical plexus.

Intercostal Neuralgia is one of the commonest neuralgias of debilitated subjects, especially women and persons of nervous temperament, and occurs oftenest in the left side. It is also met with in connection with brachial neuralgia, or with neuralgia of the thoracic or abdominal viscera. The *pathological diagnosis* should consider intra-thoracic cancer, Pott's disease, aneurism, all of which would be likely, but not certain, to cause bilateral pain, and pleurodynia. *Treatment.* Gelsemium and quinine are useful in large doses. The intercostal nerves have been successfully stretched.

Ilio-lumbar Neuralgia needs no separate notice, except to remark that it is often found in connection with affections of the uterus and ovaries.

Anterior Crural Neuralgia is not very common and needs no separate notice. The *pathological diagnosis* should consider the possibility of hip-disease, and of pelvic tumors.

Sciatica is one of the commonest and severest varieties of superficial neuralgia, both on account of the exposed position of the nerve, which renders it liable to injury both within and without the pelvis, and also from causes which are more subtle and less well understood.

The causes of sciatica are, local injuries; primary neuritis, as in herpes zoster; exposure to sudden alterations of heat and cold; intra-pelvic diseases, even when they do not directly involve the nerve itself, as uterine disease for example; gout, diabetes, and the various constitutional affections which impair the quality of the blood or the general nutrition. Cancerous disease within the pelvis may, by pressure, give rise to pain which is hardly to be distinguished at first from sciatica, and this cause should be suspected if the symptoms are bilateral, unusually persistent, or attended with marked signs of neuritis, such as anæsthesia, localized numbness and pricking, muscular wasting, and especially if other nerves are involved at the same time. Chronic inflammation of the tissues around the hip may also give rise to pains which could be readily mistaken for sciatica. It is very important, and usually perfectly easy to distinguish the pains of locomotor ataxia from those of sciatica. The former are bilateral, not confined to the distribution of the sciatic nerve, momentary in duration, and usually affect, by preference, small spots in the fleshy parts of the limb, the knee, or the heel, or dart down the leg and disappear again.

Symptoms.—The distribution of the pain in sciatica may be co-extensive with the distribution of the whole nerve, but oftener it centres in certain regions which may vary as the attack goes on. Such are the sacral region, the neighborhood of the sciatic notch, the back of the thigh, the popliteal space, the calf, the outer side of the leg, or the outer side and dorsum of the foot. Sometimes the course of the nerve itself is marked out by darts of pain. "Tender points" are found at the sacro-iliac synchondrosis, the sciatic notch, the popliteal space, behind the head of the fibula, behind the outer malleolus, and often at other places as well. Some cases of sciatica are of short duration and seem to be of purely functional origin, while in others neuritis plays a large part in the production of the symptoms, causing persistent pain, loss of sensibility, cutaneous eruptions, coldness and wasting, and increased pain on motion, voluntary or passive. Even where these symptoms are absent, and where the pain is fully intermittent, the absence of neuritis cannot be confidently asserted in cases of long standing.

The *prognosis* of sciatica depends upon its cause. Except when it is dependent upon some temporary irritation, however, it lasts usually for weeks or months, or even longer, and is liable to relapses and recurrences. The sciatica of diabetes is said to be peculiarly obstinate, even if the usual symptoms of the disease are not severe.

The *treatment* of sciatica varies with its causation and its stage (*vide* also under general treatment). The removal of diathetic taints, absolute rest, superficial blistering, counter-irritation by a spray of ether or of chloride of methyl, the local wet-pack followed by vigorous rubbing with cold water and by warm applications, galvanism with long-continued mild currents, cutaneous faradization, are always in place, and turpentine, quinine, muriate of ammonia, or salicylate of soda in full doses,

may be given in fresh cases for limited periods with some hope of relief.

In chronic cases the remedies may be proportionately vigorous. The galvanic applications may be as strong as the patient can bear, and special pains taken to localize the current on the nerve, at the sciatic notch, and in the popliteal space, by pressing the electrode inward, and seeking to excite referred sensations at the periphery. It probably makes no difference whether the anode or the cathode is employed over the nerve, or whether the current is occasionally interrupted. Indeed, a series of sudden reversals of the current are often of service. Deep massage along the nerve, even if painful at the time, may be of great value, probably by removing inflammatory exudations. Ice-bags may be applied continuously along the course of the nerve, and deep injections (*vide* under General Treatment) are serviceable, though not without danger. When other means fail, "nerve-stretching" may be used, and, indeed, under proper antiseptic precautions, it is not a dangerous operation in itself. It has, however, been shown that the effects of the traction are felt in the spinal canal, and myelitis has, in a few instances, been excited. A substitute operation is the so-called "bloodless stretching," in which, the patient being under ether, the thigh is forcibly flexed on the pelvis, and the leg extended at the knee, and this position maintained for some minutes. That the nerve can be stretched in this way is beyond question; but it may be doubted whether the method is really safer as regards its secondary effects, than that of the exposure of the nerve by a single incision, and the use of a measured amount of direct traction, upward and downward in turn.

Migraine (hemicrania, megrim, sick-headache) is a complex sensory neurosis, chiefly characterized by pain, recurring in more or less periodical attacks, each lasting from a few hours to two or three days, and referred, vaguely, to the inside, sometimes to the outside, of the head, mainly in the temporal region, usually felt on one side at a time, sometimes on both sides, and often accompanied with nausea and vomiting.

In typical cases the attacks are ushered in by complicated *auras*, analogous to those noted in the first stage of an epileptic seizure. The most characteristic of these auras consists in the appearance in the visual field of dazzling, vibrating points, or serrated figures, sometimes with prismatic outlines. These appearances are often accompanied by a temporary loss or obscuration of vision over one vertical half, or some other portion of the field, which is apt to clear up on one side, while it advances on another. At the same time a marked tingling and numbness may be felt over one-half of the tongue, one hand and arm, and even one-half of the body, and if these symptoms are present on the right side there may be temporary aphasia. It sometimes happens that these auras occur at intervals, even for long periods, without being followed by the headache, and they might then be mistaken for lesser epileptic seizures. Still earlier signs of an approaching attack are sometimes recognized, consisting in a sense of unusual lightness and well-being on the day previous, or in sensations of thirst, or of giddiness, chilliness, and the like. The headache is sometimes felt on the same side with the localized prodromal signs, sometimes on the opposite side. During the attack a drowsiness may be present, which differs from the refreshing sleep with which the seizure is apt to close. Nausea and vomiting may be present throughout, but more often toward the end of the attack.

The vaso-motor symptoms of migraine are striking and noteworthy, and the more so that they have been widely considered to be the cause of the pain and other symptoms. They consist in, sometimes a contraction, sometimes a dilatation of the vessels on the affected side of the head, or the one state followed by the other, and accompanied with other changes equally suggestive of disorder of the sympathetic system (dilatation or contraction of the pupil, increased perspiration, etc.). These vaso-motor symptoms have been considered to constitute two distinct varieties of migraine, called *angio-paralytic* and *angio-spastic*, and the pain has been referred partly to an irritation of the nerves ramifying in the vessels themselves, partly to an anæmia or a congestion of the sensitive cerebral membranes. It is certainly possible that these vascular changes may give rise to pain, and to sensory auras; but, on the other hand, vaso-motor and glandular symptoms are by no means a necessary part of migraine, and are seen to a greater or less degree in most neuralgias. Again, in a case under the care of the writer, the congestion sometimes shifts from one side of the face (or, more strictly, the ear) to the other, without a simultaneous shifting of pain.

The seat of the pain in migraine is sometimes in the occipital region, or at the vertex, instead of the frontal region; or its position, as well as its character, may be different in different attacks. The feet and hands are often icy cold, and sometimes a degree of prostration is present which is out of proportion to the pain. As an attack passes away there is often a copious discharge of limpid urine. Usually a night's sleep puts an end to a single attack, but sometimes the pain recurs on a second, and even a third day, and then generally affects that side which was at first exempt. After recovery the patient is usually free from pain for a certain period of one, two, three, or four weeks, or for a longer and less definite interval.

Migraine is a disease of youth, puberty, and middle life, and the attacks diminish, and finally disappear toward advanced age.

Periodical Headaches.—Besides typical attacks of migraine, many persons are subject to more or less regularly *periodical headaches*, in which a greater or less resemblance to migraine may be traced, though many features are wanting. These constitute, as it were, a link between migraine and the so-called *neuralgic* and *nervous headaches*, in which the pain is more diffused, the recurrence less regular, and a definite causation, such as fatigue, excitement, or indigestion, more often traceable. It is, however, a significant fact that these irregular forms are met with in the same persons and families in which migraine is common.

Clinical Relations.—Although, as will have been seen, migraine differs widely from most of the superficial neuralgias in its symptoms and clinical history, still, as has been said, it is important to consider them together, because the same neurosal tendency runs through both, showing itself in periodicity of recurrence and in the associated affection of glandular and vaso-motor nerves. Furthermore, with some patients whose headaches are, on the whole, of a distinctly typical migrainoid character, and associated with other signs of the neuropathic diathesis, the intracranial pain is often associated with a distinct neuralgia of the ophthalmic division of the fifth pair, or the two are at least interchangeable. Moreover, other superficial neuralgias, and still more the visceralgias, are common in the same patients.

Migraine is a prominent member of the neuropathic family of diseases, and as such is related closely to epilepsy, asthma, etc. It is met with in families of gouty descent, and in connection with the vaguer diseases of nutrition, such as the so-called lithæmia.

Peripheral irritations, such as those from uterine disease, errors of accommodation, or affections of the nasal mucous membrane may no doubt provoke attacks, but are rarely, if ever, the whole cause of the tendency to them.

The *treatment* should be directed, in the first instance, to the removal of all causes of the outbreaks, peripheral or constitutional. Here should be mentioned the special diets which now and then prove of great value. It is noteworthy that some persons do best on a strictly vegetarian, some on an animal diet, while with others, again, it seems to be less the character of the food that makes the difference than the change from one diet to another. If the patient is at all debilitated the nourishment should be ample, and care should be taken by enjoining regular exercise, a large amount of rest, and a simple—if possible, an out-of-door—life, that digestion is satisfactorily performed at every stage.

Cod-liver oil and the tonics (*vide* under General Treat-

ment) are often eminently in place; but there is no special treatment that will not often fail of its effect unless combined with all the means that can be devised for improving the bodily and nervous tone. Frequent changes of scene and climate, suitable and regular occupation, and occasionally such alteratives as the Turkish bath, are useful to this end. The only remedy which can be considered in any way specific is cannabis indica, which may be given for weeks, and even months, in the dose of one-third to one-half grain, combined, if desirable, with valerianate of zinc, bromide of camphor, iron, or quinine, with a hope of much benefit. When the attack is coming on it may occasionally be warded off by caffeine, in the dose of two or three grains every half hour, for two or three doses, or a large dose of guarana (f ʒ ij. of the fl. ext.), with half to one drachm of bromide of sodium.

In the management of the attack itself complete rest, a darkened room, elevation of the head, strong tea or coffee, in small but frequent doses, if necessary morphine, give as much relief as anything. As the attack is passing away bromo-caffeine and coca help to recover the usual tone.

Occasionally, when the vascular changes are marked, nitrite of amyl, or nitro-glycerine, or, conversely, ergot, in full doses, will, it is said, break up an attack. Manipulation of the head or vibration of the finger-tips is often very grateful, and a faradic current from the feet to the back of the neck may induce sleep and hasten the close of the attack. It may be supposed that these agents act in part by exciting a sort of local hypnotic action. Salicylate of soda is also said to be a valuable preventative of migraine. This drug sometimes causes albuminuria and perhaps nephritis if given in large doses, or for a long time, and its effects should, therefore, be watched.

Visceral Neuralgias.—The visceral neuralgias are of great importance, both on account of the suffering which they cause, and because of their constitutional significance. They occur, like the other neuralgias, partly from general nervous causes, such as fatigue, gout, and other constitutional diseases of the nutrition, and especially the neuropathic tendency, and partly as a result of functional and organic disorders of the viscera. To what extent actual neuritis occurs as a cause is not yet known, but it is certain that chronic inflammation of the nerves is often set up by organic affections of the organs, such as the heart, to the neighborhood of which the pain is referred.

The pain of the visceral neuralgias is usually deep-seated, vaguely located, and dull, but at the same time intense and prostrating, and sometimes attended with faintness, nausea, sweating, and often disorders of the circulation and secretions. Though not sharply localized they take their name from the organ in the neighborhood of which they seem to be situated, as the pharynx, the œsophagus, the heart, stomach, liver, bowels, ovaries, uterus, rectum, testis, etc.

Angina Pectoris (see vol. i., p. 227), though a true visceral neuralgia, is so often a symptom of heart disease that it is usually described in that connection. It may, however, be mentioned here that it occurs not infrequently, though hardly in its severest forms, entirely independently of organic disease. In a case known to the writer, for instance, it occurred during a considerable period on the slightest exertion, such as rapid walking, in a lady suffering from temporary debility from overwork, and was each time attended with breathlessness, and with pain and numbness in the left arm, yet eventually passed entirely away. Various other such cases are on record.

Dull pain felt during the intervals of the attacks is looked upon as perhaps indicating neuritis of the cardiac nerves, but in such cases cardiac disease probably exists as well.

It is an interesting question whether nitrite of amyl, which acts so well in angina pectoris of organic origin, would be beneficial also in the functional cases.

The *treatment* should be, in the first instance, tonic, and in the attacks itself diffusible stimulants and analgesics would be in place. Besides the outspoken diseases of the heart, increased vascular tension, dropsy, [illegible] for, and signs of Bright's disease, as well as [illegible] irritability of the nervous cardiac apparatus, such as result from physical overstrain and from [illegible] and other cardiac stimulants. Under these circumstances digitalis or other heart tonics might be indicated.

When the attacks are of frequent occurrence electricity, either by the superficial use of the wire brush and faradic current, or in the form of galvanism, is said to be of service, as is also counter irritation over the chest.

Gastralgia (gastrodynia, cardialgia, gastric colic, etc.) is perhaps the most common form of visceral neuralgia, and in its widest sense covers a variety of sensory symptoms, ranging from sensitiveness and pain accompanying the act of digestion, and perhaps accompanied with signs of delayed or imperfect digestion, yet not due to gastritis or ulcer, to severe paroxysms of pain entirely unconnected with the digestive process.

The *etiology* is similar to that of the other visceral neuralgias, but it is met with in young children oftener than the rest. It is especially common in gouty subjects and in persons of nervous, mobile temperament, and the writer has several times seen slight symptoms of this general character at the time of the menopause.

The pain in gastralgia is felt primarily at the epigastrium, and radiates thence upward in the direction of the œsophagus, and through toward the back, besides laterally through the abdomen. Allbutt ("Visceral Neuroses") says that it may be associated with anginiform attacks, and it may be attended likewise with superficial neuralgia of the abdominal walls and other parts of the body, as the face.

The relation of gastralgia, as well as of the other sensory visceralgias, to the functional affections of the viscera, is very important, and calls for further study. There is no question that many digestive disorders which attend gastritis, or even cancer, may also occur as pure neuroses, and it is likewise evident that there is a whole range of nervous disorders, sensory and motor, of which these purely painful affections form only one division.

Treatment (*vide* also under General Treatment).—The vices of nutrition and assimilation should be corrected, such as are seen in gout, and evinced also by a variety of nervous symptoms often described under the head of lithæmia, and sometimes attended with the presence of free uric acid or oxalate of lime in the urine. Constipation should be corrected, and the diet regulated, but not necessarily reduced to a very small amount, even if digestion is attended with pain. Sometimes it will be found that one kind of food will agree better than another without apparent reason, and, when the gastralgia is associated with serious disorders of the digestion it may be that a patient who does very badly at home will get on very well if removed from home and placed under the care of a nurse. Indeed the most significant fact to bear in mind is that, as a rule, it is the general nervous condition which needs treatment, rather than the special symptoms.

Belladonna and the antispasmodics, such as assafœtida and valerian, besides the gastric stimulants, are of more service in gastralgia and the other visceral neuralgias than their anæsthetizing influence would suggest. Morphine must be resorted to if necessary. Deep pressure sometimes gives temporary relief.

It is not necessary to review in detail the neuralgias of the other abdominal viscera and of the genital organs. Attention has already been called to the fact that affections of the *uterus and ovaries* may give rise to neuralgiform affections in distant parts of the body, or in the distribution of the lumbo-abdominal nerves; but besides this the uterine and ovarian nerves themselves are sometimes the seat of neuralgia, not to speak of the pain of dysmenorrhœa, which is, doubtless, in part, of that character.

Neuralgia of the liver is said to be sometimes attended by swelling of the liver and by jaundice; but here, as frequently in the case of the abdominal neuralgias, it is difficult to guard carefully enough against mistaking an organic disease for one of the concomitants of a neuralgic attack.

Neuralgia of the anus and rectum is a well marked and painful affection, and the tendency to it may be hereditary. The seizures may come on spontaneously, especially after fatigue, or may be excited by slight irritations, such as the passage of hardened fæces, or may follow sexual intercourse or seminal emissions. The pain may be accompanied by clonic spasms of the perineal muscles. The rapid injection of hot water into the rectum, or hard and deep pressure with some smooth object will often stop the attack, which otherwise is liable to last for one or two hours.

Besides the more or less typical neuralgias there are a number of other painful affections, of spontaneous origin or provoked by trifling irritations, and of unknown pathology, which occur usually in persons of neuralgic or neuropathic tendency, and are, therefore, fairly to be classed as neuralgic, although they do not follow the distribution of a special nerve. Such are pains referred to the skin, the muscles, or the joints, not attended by signs of local inflammation or by any appearance of local congestion or anæmia, and capable of coming and going with greater or less rapidity. The "growing pains" of anæmic children are of this order, together with a similar affection sometimes met with in adults; also the "general neuralgia" of anæmic patients, and those dermatalgias which are not due to the organic irritation of sensitive nerve fibres, such as occur in locomotor ataxia and neuritis. The arthralgic pains of false (hysterical) joint-disease might perhaps be included.

The therapeutic indications are, primarily, to improve the constitutional and nutritive condition, and to relieve the pain by local or general baths or liniments, or by anodynes. *James J. Putnam.*

[1] Valeur thérapeutique de l'élongation des nerfs. Paris, 1886.

NEURASTHENIA. The term *neurasthenia* ("*nervousness*," or *nervous weakness or prostration*) has come, of late, into general use to indicate certain states of the nervous system of which the anatomical basis is unknown, but which are characterized, on the one hand, by a lack of vigor, efficiency, and endurance, affecting usually a large number of the nervous functions, and, on the other hand, by signs of active derangement, which in part seem to occur as positive symptoms, and in part are due to a failure of the mutual support and control which the different parts of the nervous system afford each other in health.

In its widest sense the term neurasthenia is used as covering the groups of symptoms usually indicated by such names as *nervous prostration*, *spinal irritation*, *neuropathic or neurotic diathesis*. Even abnormal mental states, such as mild degrees of melancholia and "morbid fears," are often classed as neurasthenia, but their relation to a more serious malady should not be forgotten.

Sometimes neurasthenic symptoms are secondary to localized pathological affections in one or another part of the body, and this fact has led some observers to recognize in neurasthenia only a symptom of errors of refraction, lithæmia, uterine disease, organic disease of the brain or cord, and the like. It would, however, be easy to push this attempt too far, and the writer certainly believes that neurasthenia is a useful term to indicate states of nervous weakness which are often primary, and which, even when secondary, usually imply a pre-existing basis of functional disease.

It has been said with some truth that hysterical and hypochondriacal persons are always neurasthenic, but that neurasthenic persons are not always hysterical or hypochondriacal; and hysteria has also been spoken of as "nervousness" crystallized into the form of a definite disease. Although typical cases of neurasthenia and of hysteria differ widely, yet the two affections run into each other, and the same patient may, at the same moment or at different periods, show symptoms of both diseases.

While it is true that neurasthenia should be looked upon—relatively to hysteria and insanity—less as a distinct disease than as a departure from health, and as an expression of the mode in which degeneration of the nervous powers first shows itself, still it must not be forgotten that neurasthenics present certain symptoms which are almost as characteristic as those of any other of the neuroses.

SYMPTOMATOLOGY. — The symptoms called neurasthenic are conveniently divided into those which arise as a sign that the patient is unequal to the ordinary tasks of a fairly healthy person, and those which are manifestations of a morbid action on the part of the nervous system over and above the indications of simple inefficiency. These can be called, for convenience' sake, *negative* and *positive* symptoms, respectively. Thus, the *negative* symptoms are those of fatigue or pain arising without sufficient cause, but still due to effort, and, within certain limits, proportionate to the effort made; while the *positive* symptoms are nervous outbreaks or signs of excessive weakness of special kinds, occurring almost independently of effort, and at least out of proportion to it. The negative and positive symptoms may run into each other, as, for example, when, in the place of an over-sensitiveness or self-distrust, we find an ever-present sense of anxiety or "morbid fear;" or, when a simple incapacity of the eyes to bear a prolonged strain passes into a high degree of photophobia or asthenopia; or, when instead of a simple feebleness of the digestion we have an active nervous dyspepsia, and so on through the whole range of nervous functions. Usually the symptoms of special nervous derangement appear on a background of general nervous weakness. It sometimes happens, however, that some one symptom is so prominent that it seems to stand almost alone. In like manner, some cases present almost exclusively mental symptoms, and cannot bear a slight emotional strain without great suffering, and yet may show more than ordinary physical strength and endurance; while with others by far the most prominent symptoms affect the muscular and vegetative functions.

The late Dr. George M. Beard,[1] to whom we owe many valuable observations on this subject, attempted to base upon this fact a division of neurasthenic symptoms into cerebral and spinal, but this is premature, and is not based upon sufficiently well-grounded reasoning.

Individual cases of neurasthenia vary so greatly in the grouping of their symptoms that it will be better to study the symptoms themselves, one by one, rather than to attempt to describe different types of the disease. It is, however, worth while to bear in mind that the term "irritable weakness" aptly indicates the character of many of the conditions met with.

Special Symptomatology.—The *temperament* of neurasthenics is essentially mobile. They are usually quick, versatile, and sensitive, and may be talented and intellectual, though they rarely have the robustness and endurance necessary for great success. Often a sense of nervous weakness and effort is present, which gives rise to self-consciousness and self-distrust, and finally to a suspiciousness toward others, and to a vague feeling of isolation and dread.

A healthy organism should respond to calls upon it with an elasticity like that with which the cushion of a billiard-table responds to the blow of the ball.

With neurasthenic patients this is usually not the case. A trifling impression arouses an exaggerated *inward reaction* in the form of egotistic or self-distrustful ideas, while the *outward reaction* is correspondingly feeble, or unduly delayed. Slight obstacles seem mountains, and some patients can hardly persuade themselves into a decision or an exertion, although under the influence of some slight excitement they may act with energy and intelligence. A similar undue inward reaction is shown in other departments of nervous energy besides the strictly mental. Thus, even with patients who seem well-balanced and of good self-control, trifling causes may excite or maintain neuralgia or dyspepsia, disorders of the sleep, collapse of strength and the like, with provoking and inexplicable readiness.

Instead of the vague sense of anxiety and dread, special "morbid fears" are often present. The variety of these fears is endless. Among the most common is the fear of large open spaces, fear of crowds, of walking

alone, or riding in railway trains, fear of contamination from touch, fear of taking food, and the like. These symptoms should, perhaps, be classed under the head of monomania, and not of neurasthenia, but no sharp dividing line can be drawn between the two.

Sometimes the neurasthenic temperament approaches the hysterical temperament, in exhibiting gross selfishness and fondness for exaggeration, and for attracting attention, but, as a rule, neurasthenic patients are docile, patient, self-sacrificing, and intelligent, or, if they are selfish, it is because of a life of semi-invalidism, or of habits of painful introspection, and is not due to a lack of moral sense, which is rather characteristic of the hysterical temperament.

On the other hand, it is not uncommon to see neurasthenic patients exhibiting some of the special disorders which are usually considered as peculiar to hysteria, such as hemiplegic disorders of sensation or motion, alteration of the deep reflexes, photophobia, etc.

The *digestive disorders* of neurasthenia may vary from simple feebleness of the digestion, or digestion perhaps sufficiently well performed but attended with pain, to disturbances almost or quite indistinguishable from true catarrhal affections. Such patients are also very subject to visceral neuralgias, which, when they affect the nerves of the digestive tract, are often attended with marked signs of functional disorder of the corresponding organs.

Other symptoms are likewise met with, which are hardly to be called digestive, though affecting the digestive organs. Such are attacks of nausea, not due to the taking of food; attacks of diarrhœa, or, more strictly, discharges of watery fluid, coming on suddenly as a result of slight nervous fatigue or excitement, and passing away as quickly, or perhaps permanently yielding to an improvement in the patient's general condition; or discharges of large quantities of mucus, in masses or strips, with or without fæces.

These nervous disorders of the digestion are of so much practical importance and interest that they have of late years attracted much attention.

Often the only conclusive diagnostic sign to distinguish them from organic affections is the fact that they do not improve under the usual treatment for gastro-intestinal catarrh, chronic ulcer, etc., which they simulate, while they are greatly influenced by improvement in the patient's general condition and surroundings. Thus, a removal of the patient from home, or his subjection to the "rest-cure" (see under Treatment), may effect what the most careful dietetic and medicinal treatment had failed in years to accomplish.

Finally, it is not to be forgotten that in any given case the symptoms may be in part of organic, in part only of functional origin.

In some cases the neurotic dyspepsias are so severe that, what with the nausea and vomiting and general distress and pain, the patient's strength is greatly reduced, and his life may even be threatened. In two cases under my care, these symptoms were attended with symptoms of insanity of the melancholic type, and with suicidal tendency.

Sensory Disorders.—The most important type and instance of the disorders of special sense is simple *asthenopia*, which is often so severe that some patients, who may have, otherwise, no more serious trouble than a certain delicacy of health, are, for years together, almost totally unable to use their eyes for any fine work. This may be due in part, or wholly, to weakness of the muscles of convergence and accommodation, and is sometimes remarkably relieved by a systematic method of exercise, proposed by Dr. Ezra Dyer, of Newport, R. I., combined, if necessary, with suitable glasses. Other patients are much annoyed by sparks of light floating in the field of vision, or by glimmering sensations similar to those which often precede sick headache. Tinnitus aurium is sometimes found, but this is less likely to be a prominent symptom in simple neurasthenia, than to occur as a sign of irritation of the nervous centres, such as occurs in so-called lithæmia.

Neurasthenic patients are subject to [illegible] neuralgiform attacks, both superficial and visceral, and usually shifting and fugitive in character (see under Neuralgia), and to periodical headaches.

Backache, sometimes with excessive sensitiveness to light pressure over the spine, is very common, and may be associated with some slight uterine disorder, though it may also occur alone. It is usually increased by exercise, and especially by using the arms above the height of the shoulders, and by anything which causes general fatigue.

The pain of the neurasthenic backache may be along the vertebral column, or further outward, especially about the sacral and iliac attachment of the large muscles of the back. It is often provokingly obstinate under local treatment, and disappears the soonest under such treatment as best agrees with the patient's general condition.

Sometimes, in the class of cases to which the name of "spinal irritation" was formerly given, the sensitiveness of the back to slight pressure, combined with the local pain, is the most prominent symptom present. In such cases, besides the local sensitiveness, the pressure gives rise to special peripheral sensations, thoracic, pulmonary, abdominal, etc., according to the level at which it is made.

Pain in the muscles and joints is not uncommon, without it being possible to discover any sign of typical rheumatism, gout, or neuralgia, and this symptom, like so many others, is capable of attaining a prominence out of proportion to the rest. Thus, in the case of a gentleman of whom I have had the care, intense muscular pain in the legs, beginning after an interval of quiescence of half an hour, and rising steadily in severity, is brought on so easily by the least exertion that the patient has been obliged for many years to give up walking almost altogether.

Another very common variety of pain, not precisely neuralgic, is a distressing *sense of pressure at the vertex or occiput*, often combined with tenderness and stiffness of the muscles of the neck (Kopfdruck, Runge, "Arch. f. Psych.," etc., vol. vi.).

This is usually a sign of some special fatigue or strain, but some patients suffer from it almost continuously, and find in it a source of serious distress.

Paræsthesia ("prickling and numbness") in the extremities, or assuming the hemiplegic distribution, is likewise often complained of, but it is to be remembered that the same symptom is met with in debilitated women who are not especially neurasthenic, in cases of chronic lead-poisoning, and in other conditions.

Palpitation and *cardiac irregularity* are not uncommon, and I have seen one or two patients with peculiar *disorders of the respiratory rhythm*. One of these was cured by systematic exercises of the respiratory muscles.

Nervous cough is sometimes a marked and obstinate symptom, and may last for months, without any (local) cause whatever, and then pass quickly away. These coughs, like many other of the neurasthenic symptoms, are associated at times with slight irritation in the nose, or pharynx, or ears, or in the genital tract. Sometimes, instead of the cough, we find a veritable *asthmatic seizure*, and in this connection the semi-neurotic origin of hay-cold is to be remembered.

It is not uncommon to see in patients, who cannot be called other than neurasthenic, an almost *periodical recurrence of symptoms*, such as migrainoid headaches, attacks of exhaustion, sleeplessness, and the like. Usually some slight over-exertion or fatigue seems to act as the immediate cause of these outbreaks, but the cause and the effect are out of proportion to each other.

Neurasthenic patients are, as a rule, very easily affected by *stimulants* of every kind, and at the same time they often feel rather a desire for them. In spite of this, they are by no means always inclined to be immoderate in indulgence, and need not necessarily be advised to abstain altogether from their use.

Insomnia, in one or another form, is almost always present at one time or another, and forms one of the most important symptoms of neurasthenia, on account of its

indirect effects as well as for the suffering that it occasions. The early morning period of wakefulness is a time when the depression of spirits, from which neurasthenics often suffer, makes itself most prominently felt.

It is also true, however, that such patients usually sleep more than they themselves believe, and that they do not suffer from an amount of real fatigue at all in proportion to their sensations in the morning after a night of restlessness and unpleasant dreams. Excessive *drowsiness* is a less common symptom than insomnia, and, though annoying, less serious in its results.

Vaso-motor Symptoms.—Besides the fact that nervous patients are prone to blush easily, a fact which usually indicates only a general emotional excitability, they often show symptoms which are fairly attributable to a morbid action of the vaso-motor nervous system. Such are the vascular spasms of *digiti mortui*, chilliness, and urticaria, and the vascular dilatation which causes erythematous patches, burning, and swelling of the hands and feet, and even chilblains.

The general sensation of heat, which leads certain patients to go about with light clothing in the coldest weather, is probably not really of vaso-motor origin, nor have we a right to attribute to this cause the attacks of profuse sweating on the slightest exertion from which neurasthenics occasionally suffer, or the watery discharges from the bowels already alluded to. It is more probable that these are neuroses of the glandular nerves themselves.

The "hot flashes" which are often such a serious annoyance, are sometimes attended with visible flushing of the face, hands, etc., and with distressing sensations of fulness and pulsation in the head—symptoms which are probably vaso-motor in character; but sometimes they are unattended by any such phenomena, and so far as we know, are neuroses of sensation only, and analogous to the many other morbid feelings with which such patients are liable to be attacked.

The *sexual functions* are apt to be disordered in various ways. Impotence, premature ejaculation, sense of prostration after sexual intercourse, and similar symptoms, are much oftener met with among neurasthenic than among healthy persons; and it is with persons of this class, both male and female, that irritations in the genital tract produce, indirectly, their most serious results. The sexual instincts in neurasthenics are usually active and practically normal, the grave perversion of desire belonging rather to the category of insanity.

The *general nutritive condition* of neurasthenic patients may be good, and their muscular strength quite up to the normal.

They are, however, usually spare in flesh, and if, as often happens, their appetite, digestion, and power of assimilation are disturbed, they may become greatly reduced in health. On the other hand, many of these patients, and some of the worst cases, are over-fat, and often at the same time anæmic.

The *metabolic functions* are apt to be at fault, and indeed, strictly speaking, it is often impossible to say whether the nervous or the nutritive disorder comes first. Free uric acid, urates, or oxalate of lime are often found in the urine; the phosphates are liable to be increased, and the quantity of the urine may be increased or diminished, or both in turn.

Where such conditions as these are traceable to functional diseases of the liver, or to a gouty inheritance, or to the absorption of products of imperfect digestion, the nervous symptoms which occur may fairly be considered as secondary.

On the other hand, there is little or no doubt that the nervous weakness may be the primary affection, and, even in many cases of gouty parentage, it is probable that the impaired nervous system is often a direct inheritance.

The *pupils* are apt to be unusually large in moderate light, and very mobile.

The *voice* sometimes shows signs of the universal tendency to irritability and weakness, and lacks the normal firm, sonorous quality.

The *hair*, *teeth*, and *skin* of neurasthenics are said by Beard to suffer from premature demutrition; but this is difficult to prove with certainty, though it may be admitted as possible that a lack of nervous vigor should show itself in this direction as well as in so many others.

The following sketch by Dr. Clifford Allbutt[5] may be quoted as giving an excellent picture of one variety of neurasthenic patients.

After speaking of the contrast between the neurotic and the hysteric types, and the absence in the former of the exaggerated selfishness and feebleness of purpose, which are characteristics of the latter, he says: "He enters your room with a brisk step and a quick, observant eye. You see a slightly built, meagre man, of sallow complexion, or, if colored, with the color painted high upon the cheek-bone. The cheeks and temples are hollow, and the temporal arteries are visible under the lean skin, which often shows tanned markings, deepened during attacks of pain; the hair is straight, fine, and sparse upon the scalp; the features are sharp, often prominent; the lips thin, and the skin dry; and some remnants of eczema may be seen about the chin or ears. The bodily frame is lightly and often finely built, the bony fingers and wrists and the visible sinews and radials betraying the absence of fat. Here and there, in later life, a knotty knuckle may tell of gouty parentage. The pulse, when most tranquil, usually ranges between seventy and eighty, and accelerates on the least excitement. The clavicles and ribs in like manner are prominent, and the heart's apex may be seen to beat sharply before the eye; its systole to the ear is likewise short and sharp, and the second sound very audible over a wide area. The limbs are small, but often very sinewy; such persons are as active as birds, and the absence of fat in their muscles often gives to these, in states of health, the quality of hardness under the hand. Their conversation, again, is lively and voluble, often keen and brilliant, but impressionable rather than imaginative; you may generally notice in them, too, some little blinking, twitching, or tattooing trick which quickens as thoughts and words come faster. His companions will tell you that he is subject to great fluctuations of the animal spirits; gay, even fascinating, in society; brisk, orderly, and thorough in business; but at home dejected or fretful. He is a small eater, a light sleeper, and a worn worker. These persons are the heirs of every true neurosis, from insanity to toothache; and, on the whole, when we consider the infinite perturbations of intermarriage, it is surprising how true they run, or how clearly you may detect the neurotic strain in mixed descendants. Of their visceral neuroses I shall have to speak hereafter, and would only say now that in both sexes of them migraine, stomach-ache, and windy colic are frequent and eminent, and receive the name of dyspepsia; and in the women are added to these uterine and ovarian neuralgias and hyperæsthesias. To call these suffering women of the neurotic type hysterical is to confuse all due acceptance of names, and, what is worse still, is to confuse the real relations of things. The neurotic woman is sensitive, zealous, managing, self-forgetful, wearing herself for others; the hysteric, whether languid or impulsive, is purposeless, introspective, and selfish. In the one is the defect of endurance, but in the other defect of the higher gifts and dominion of mind."

Besides this, which might be called the intellectual type of neurasthenia, there is another, in which the element of feebleness, mental and physical, is the predominating characteristic. Many of the "fat anæmics" belong to this class, and in them, in lieu of excitability and misdirected force, the nervous symptoms suggest those of hysteria, of a mild type, in their exaggerated response to slight irritations.

Influence of Age and Sex.—Neurasthenia, unlike hysteria, is almost as common among men as among women. In its full development it is a disease of puberty and middle life, but signs of the neurasthenic tendency are to be found in early youth, consisting in a general mobility of temperament, oversensitiveness, and precociousness, and the occurrence of special nervous

symptoms, such as insomnia, somnambulism, chorea, night-terrors, etc.

Still later, especially in young women from sixteen to twenty years of age, various other signs of nervous weakness may make their appearance, such as headache, backache, extreme and causeless lassitude; and these years constitute in fact a critical period, during which many persons are nervous invalids, who may later re-acquire good health. Very often these periods of prostration are attributed to special causes, such as falls, overexertion, and the like, but these events are rarely more than exciting causes, and are not necessary to the result. Such attacks are often diagnosticated as anæmia, or chlorosis, or as "spinal concussion," but their failure to respond to ordinary tonic or local treatment, and the fact that they are often relieved by means addressed to the general nervous condition, point to their true origin. Of course, true anæmia may complicate this condition of nervous prostration, or even act as its cause, and may require its own special treatment; but the important point is that the nervous element in the case is not to be overlooked.

Course and Prognosis.—Neurasthenia is not likely to shorten life to any marked degree, unless it causes severe disorders of the nutrition. It does, however, occasionally happen that a patient dies from no other apparent cause than a prostration of the nervous functions.

On the other hand, neurasthenia is not, as a rule, an acquired disease, but an inherited weakness of the nervous system, and in this sense is not, strictly speaking, curable. It is, however, often possible to remove the patient from the circumstances which call out the manifestations of this weakness, and thus practically to effect a cure. Sometimes, even with the best of treatment, partial improvement and frequent relapses are the rule. Constant watchfulness and good judgment rarely fail to bring some amelioration. Acquired neurasthenia may pass away with the cessation of its cause, or may overlast this for many years, as in some cases of railway accidents, or similar injuries, and in the case of neurasthenia of the menopause.

Neurasthenic symptoms sometimes constitute the first stage of outspoken mental disease, but, on the other hand, patients may be severely neurasthenic all their lives long, without suffering from more serious mental trouble.

The relation of neurasthenia to organic disease is obscure, but very important.

The fact that neurasthenia is so often associated with disordered metabolism, and with impaired nutritive vitality of many tissues of the body, and that its course is often marked by the frequent occurrence of functional disturbance of the heart and vaso-motor system, makes the inference natural that the nervous disorder must sometimes pave the way, or, more strictly perhaps, mark the commencement of more or less serious organic affections.

Our opinion in the matter, as regards chronic neurasthenia, is at present limited to this inference. We do, however, know that *acute* mental strain may be the starting-point of such affections as chronic nephritis, diabetes, and probably many other disorders. An interesting series of facts bearing on these points has been recently presented in a lecture by C. K. Mills, of Philadelphia, in the Toner Lecture upon "Mental Overwork and Premature Disease among Public and Professional Men."

Diagnosis.—This has been sufficiently covered by the foregoing sections. It cannot, however, be amiss to recall again that the presence of neurasthenic symptoms only shows that the efficiency of the nervous system has received a blow of some kind, and leaves still before us the task of seeking the real source of mischief. It is especially important to recognize that some organic diseases, such as disseminated sclerosis or cerebral tumor, may cause neurasthenic or hysterical symptoms, and perhaps for a time no others.

Etiology.—Neurasthenia must be distinctly counted as belonging to the great family of neuroses, and is inheritable from parents suffering from any one of this group of affections. It stands also in a similar relationship to various constitutional diseases, such as gout, phthisis, anæmia, and other less well marked disorders of the nutrition (dithæmia), as well as to all of those many influences which impair the vigor of the nervous system, including even organic disease of the nervous centres.

Chief among the causes that tend to develop and maintain the neurasthenic tendency may be mentioned an irregular, unhealthy, and overstimulating life, especially at the time of childhood and puberty, when the emotional nature is so active; and, at a later time, exposure to responsibility and worry greater than the patient is fitted to bear.

Some patients are, in fact, neurasthenic only in relation to their surroundings, and appear healthy when under conditions more suited to their powers and character.

One-sided, or unsystematic education in youth, or in early professional life, which makes success in later years possible only at the cost of undue strain, is a fruitful source of mischief.

It has been said that neurasthenia is more common in America than elsewhere, and that the cause of this consists partly in the peculiarities of the climate, partly in the fact that we have been brought rather rapidly under the influence of an overstimulating state of civilization. These statements and arguments are suggestive, but cannot be asserted positively without further proof.

Among the special causes of neurasthenia may be mentioned disease of the uterus and ovaries in women, and of the prostate gland in men; also concussion accidents, fright, grief, or mental strain. A condition of nervous exhaustion, which may be called acute neurasthenia, may be due to excessive overwork, as has been already alluded to.

Some of the more local neurasthenic symptoms may also be excited by irritations in the sensitive mucous tract, especially of the nose, and by errors of refraction in the eye.

Treatment.—The first indication for treatment is, of course, to remove special causes of the neurasthenic state, such as gout, lithæmia, anæmia, errors of refraction, disease of the uterus and prostate, chronic fatigue, etc. It is often found, however, that this attempt is less successful than had been anticipated, because the true relation between the symptoms and their causes had not been made out.

It is also noticeable that the neurasthenic condition can be largely relieved by appropriate general treatment, even while the irritation that caused or maintains it still persists.

The treatment of uterine disorders especially may, on this ground, often be postponed to advantage, until the general health has been partially restored by other means, or at least until the confidence of the patient has been fully gained; for, except under these conditions, the local treatment may do more harm than good.

On the other hand, it sometimes happens that an irritation in some part of the genital tract is maintaining the nervous symptoms, to such a degree that no advance can be made until this is cured; and it is a question which the judgment of the physician can alone decide, whether such an emergency is present or not.

The removal of diseased ovaries is sometimes imperatively indicated.

Whether healthy ovaries should be removed is much more doubtful, but the operation has occasionally been followed by favorable results. On the whole, the sentiment of gynæcologists at present is against it, except as an extreme measure.

The next indication is to secure that perfection of nutrition for the nervous system which will enable it to work at its best; and to place the patient in surroundings suited to his individual powers and needs. Where this is distinctly impossible, the aim should be to enable him to bear the strain imposed upon him with as little cost as possible.

As has been said, many persons are neurasthenic only in relation to their surroundings, and enjoy good health when leading a simple life, or while in the country, though they cannot stand the excitements and responsibilities of the town. Many persons break down under the strain of

emulation and competition, who can do good and active work if freed from these influences. They must learn to estimate their endurance justly, and not to be misled by their excitable temperament into attempting too much.

When the needed change cannot be secured, the time of labor should be shortened by an hour of recreation and rest in the middle of the day, or by early bed-hours. Patients who do not sleep well should not work later than the early evening hours.

If exercise can be taken freely, this furnishes an immense resource, where rightly used, and even when vigorous exercise is not well borne, as is very often the case, especially if the patient is at the same time exposed to other sources of fatigue, neurasthenics almost always gain by being a great deal in the open air. The subject of exercise is so important that it must be worked out in detail for each case. Where horseback-riding, rowing, tennis, etc., are to be had, the problem is relatively simple; but for ladies, and in winter, recourse must be had to such amusements as battledore, some thorough system of calisthenics, frequent short walks, and the like, and to rubbing with a wire or hair flesh-brush, either dry or moistened with water, or salt and water.

Neurasthenic patients are, from the want of confidence in their strength, apt to fall into unsystematic habits of life, or to be without a regular occupation, and both these wants should be carefully met. Frequent short intervals of recreation, and frequent change of scene are useful, unless incompatible with proper regularity of life. Almost any change is apt to work well at first.

The strict observance of regular hours of work, rest, and exercise often saves much wear and tear, and makes the difference between an efficient and a useless person. Even a very feeble person can have some real interest, and take some real part in the work of life.

Patients with feeble nervous systems are usually better when taking as much food as their digestions allow, and that is commonly more than their appetites would suggest.

In spite of "delicate stomachs," if the nervous strength is withdrawn from other directions and turned to the service of the digestion, such persons can usually greatly increase their food without much difficulty. As a rule, the most suitable kind of food is that which agrees best with the digestion, but in certain cases great benefit is obtained from special diets (see Gout and Lithæmia). In some cases of sick headache I have found a distinct advantage in alternating between the albuminous and the vegetable diets.

Thoroughly cooked and strained oatmeal, or Mellin's Food, with warm milk, can be taken as a matter of routine, in the forenoon and afternoon (not always well borne at this latter time) and at bedtime, or one or two eggs, boiled or raw, or scraped meat mixed with bread-crumbs and slightly broiled, may be substituted.

The *medicinal* treatment of neurasthenia is mainly useful in correcting the disorders of nutrition with which the nervous symptoms are associated. Of the drugs that are thought to improve directly the vigor of the nervous system, only arsenic, cod-liver oil, phosphide of zinc, and perhaps ergot, are of much value.

The temptation is strong to exaggerate the anæmic element in neurasthenia, and to give iron largely, but this is not advisable, unless distinctly indicated.

Electricity, in the form of galvanization of the head, general faradization, and electric baths, and a variety of *hydropathic* measures are sometimes of distinct service. The simplest method of using electricity is to pass the faradic current from the neck to the feet and hands alternately, for fifteen minutes or half an hour, daily.

For the more complicated methods, the special text-books must be consulted.

Frequent plunge-, sponge-, and even douche-baths, such as can be arranged for in any house, are an excellent tonic, and may, if desired, be made to serve as a reason for interrupting the employment of the day, and an agreeable and useful prelude to an hour's rest at noon.

The subject of hydropathic treatment, as given in the special establishments, cannot be discussed here.

For some cases of neurasthenia, where the patient is able to go about and take part in active duties, the above treatment is sufficient; for others, further means are needed to meet special symptoms, or to overcome an amount of prostration such as confines the patient to the bed or house, or totally unfits him for any active employment.

In order to treat successfully the *mental symptoms* of neurasthenia, the physician must thoroughly win the confidence of his patient by attention, kindness, and by showing self-confidence and authority, and must provide suitable employment for his thoughts, as a basis for special advice.

The *nervous indigestion* is in most cases best treated by a careful attention to the general condition, including, if necessary, removal from home, etc.

The food should be simple and digestible, but it is striking how little these cases, in spite of the violence of the symptoms, are benefited by attention to the digestive functions, such as is required in true catarrhal gastritis.

A similar statement may be made with regard to the other special symptoms of neurasthenia. They may all be helped somewhat by such symptomatic treatment as would naturally suggest itself, but as a rule they are to be taken as a sign of general nervous weakness, and require general treatment.

It has been said, with truth, that neurasthenic patients are cured, not by physic, but by the physician.

Nervous indigestion is often benefited by electricity (faradic or galvanic current, or both combined in one circuit) used as a general tonic, or applied directly to the epigastrium, with one pole at the back of the neck.

Such patients should also abstain from active exercise after eating.

The cases of pronounced invalidism require a special consideration. Although they need to be treated on the lines which have been already laid down, it is for them that the so-called "rest-cure," elaborated and practically invented by Dr. S. Weir Mitchell,[3] is so pre-eminently useful. For patients who are so reduced in strength, and nervous vigor and self-confidence, that they become more deeply implicated the more they struggle to free themselves, the rejuvenation often secured through this means is remarkable. For some of them, it is the moral element in the "cure" which is the most important, for others the opportunity for nutritive improvement.

The "rest-cure" consists of several parts—seclusion, generally with removal from home and complete rest in bed, during six or eight weeks; forced feeding, massage, and electricity. This system may be modified or simplified to suit special needs, but in severe cases there is no part of it that can be safely omitted. The complete removal from responsibility and care, from unhealthy and familiar surroundings, the anxiety of friends, and most of all, from a vague sense of responsibility as regards themselves, which the enforced rest involves, gives a feeling of mental repose, like that afforded by a long sea voyage to a person simply fatigued by overwork.

The *food* consists at first of skimmed milk,* given in small quantities every two hours, and rapidly increased until the patient takes two quarts daily. Solid meals are then gradually added, so that soon the patient is taking a very large quantity of nourishment, and in the absence of all other calls upon his nervous strength, digests it perfectly well.

Massage † is given once, or even twice, daily, taking the place of voluntary exercise. The latter is absolutely forbidden, even to the extent of feeding one's self, with the result that the patient, having no excuse for feeling tired, soon loses even the apprehension of fatigue. After a time muscular exercises are added to the massage,

* Milk mixed with half its bulk of oatmeal jelly answers an admirable purpose.

† The writer has found the application of the wet-pack or blanket-pack for an hour or less, as recommended by Dr. Mary Putnam-Jacobi (Massage and the Wet-pack in the Treatment of Anæmia), a useful adjunct to the massage.

and eventually substituted for it, and the patient is gradually allowed to walk.

As the patient is obliged to lie constantly in bed, it is important that her time should be sufficiently occupied, and this is not difficult, especially if she has a private nurse of the proper temperament and experience.

The following was the daily schedule of a patient of the writer's, and may by taken as a typical specimen: 7 A.M., Small cup of black coffee; patient allowed to brush her teeth. 7.45, Hands and face washed, fire made by nurse. 8, Breakfast, which at this time consisted mainly of a pint of gruel (taken slowly, and kept warm when desired, by table-lamp). 8.30, Sponge-bath; bed made. 9.30, Windows open for half an hour (the weather being cold the patient was warmly covered except for the face). 10, Breathing exercises; food. 10.30, Hands and feet exercise, followed by reading aloud for fifteen minutes. 11.30, Temperature of body taken, and patient rolled in blankets. 12, Food. 12.30, Temperature taken and bath given. 1 P.M., Massage and rest. 3, Hair brushed, reading aloud. 4, Food; breathing exercises. 7, Hands and feet exercise; patient arranged for the night. 8, Food. 10, Food.

In some cases I have given patients breathing exercises to carry out every hour or two; and, as a commencement of more vigorous exertion, have had them roll over from one side of the bed to the other a certain number of times. These hints from personal experience are offered, not as constituting material modifications of the treatment as laid down by Dr. Mitchell, but as likely to prove useful where the full treatment cannot be carried out, which so often happens.

The cases which are the most benefited by the rest-cure are those where the nervous symptoms are caused or maintained mainly by simple anæmia or impaired nutrition. Even in the purely "nervous" cases, however, an occasional treatment of this kind often gives a chance to start fresh once more, which is invaluable.

Some cases are not helped at all in this way. This may often be suspected beforehand, but sometimes a fortnight's trial must be given them (Playfair), and if this is explained to them in advance, they are usually stimulated to do their best.

Perhaps the most indispensable condition for success is that the physician should gain and keep the fullest confidence of his patient. How he will best accomplish this must depend, in the end, upon his own character and temperament. *James J. Putnam.*

[1] Nervous Exhaustion. New York, 1880.
[2] Visceral Neuroses, p. 21. London, 1884.
[3] Fat and Blood; and Nervous Diseases, Especially of Women.

NEURENTERIC CANALS. It is now known that during the very early stages of the development of many vertebrates there is an open communication, or series of communications, between the posterior portion of the medullary canal (spinal cord) and the entodermic or intestinal canal. To all of these communications, of which at least three distinct ones are known, the name of neurenteric canal has been indiscriminately applied. The most constant and best known of these canals is the blastoporic (see Blastopore, vol. i., 530, 531), which is identical with the "Chordacanal" of certain German writers (see Notochord). As previously described, the blastopore is the extension of the entodermic canal through the posterior portion of the primitive streak to the exterior. The neural ridges or medullary folds extend around and *behind* the blastopore, which, therefore, opens into the posterior extremity of the medullary groove. If now the canal is open at the period of development when the medullary groove is deep or has already closed over, making the medullary canal, then there is a direct communication between the entodermal canal on the one hand and the spinal canal on the other. This communication is called by several writers the neurenteric canal. It exists temporarily only, and is readily identified by its position directly after the caudal extremity of the notochord, or by the notochord ending in its wall. We owe to Balfour the identification of this canal as the blastoporic. It might with propriety be termed the false neurenteric canal or the canal of Kowalewsky, from its discoverer. Kowalewsky first found it in amphioxus, and subsequently demonstrated its occurrence in various fish types.

The second canal lies in front of the true blastopore and traverses the notochord. According to Durham,[4] it can be well seen in longitudinal sections of early stages of the frog (Fig. 2489) as a short canal, *ne.*, opening widely into the entodermal cavity. Compare also Götte's[7a] description of the neurenteric canal in Bombinator. It may be called the Gasserian or true neurenteric canal, as it seems to be homologous with the neurenteric canal discovered by Gasser[6] in goose embryos. Braun[3] has shown that both canals may be present in various bird embryos at a stage when there are six or eight pairs of myotomes and the development of the tail is just beginning. The Gasserian canal lies a short distance in front of the blastoporic or chordacanal, which is the larger of the two. The two canals appear in some species at the same time, or in other species at slightly different stages. The posterior canal is more often obliterated in birds than the anterior. In the duck and in Motacilla flava the canals are separated both in the times and positions of their occurrence; in the Australian paroquet they are both present contemporaneously, although the Gasserian passage becomes open earliest. Fig. 2490 represents a transverse section, which passes through the Gasserian canal of the paroquet. In the common fowl the blastoporic canal appears not to be open at any period after the formation of the primitive streak.

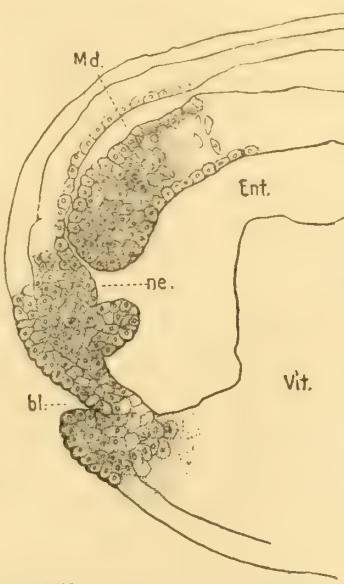

FIG. 2489.—Longitudinal Section of a Frog's Ovum shortly after the Closure of the Medullary Groove. The blastoporic canal, *bl.*, is only partially cut, but was found open in neighboring sections. (After Durham.) *Md.*, medullary canal; *bl.*, blastopore; *Vit.*, yolk forming the floor of the entodermic cavity, *Ent.*; *ne.*, neurenteric canal.

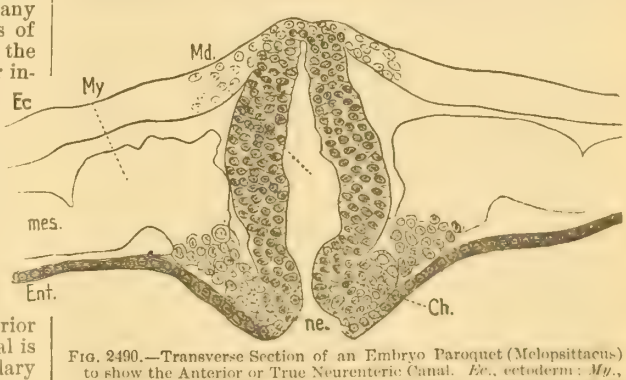

FIG. 2490.—Transverse Section of an Embryo Paroquet (Melopsittacus) to show the Anterior or True Neurenteric Canal. *Ec.*, ectoderm; *My.*, myotome; *Md.*, medullary canal; *Ch.*, notochord pierced by the short neurenteric canal, *ne.*; *Ent.*, entoderm; *mes.*, mesoderm. (After Max Braun.)

The third canal, which was first satisfactorily described by Braun,[3] occurs in older embryos. The "Enddarm" of Gasser and Kölliker becomes the "Schwanzdarm"

(post-anal gut. Balfour of older embryos, which soon becomes divided, at least in birds into a dilated terminal portion and a narrower neck communicating with the intestine proper. The posterior section then subdivides, and its narrow end-segment lengthens out and unites with the spinal cord. This neurenteric canal we may designate as Braun's canal. It is not improbable that it is homologous with the amnio-allantoic canal of Gasser,[7] which Rauber[12] has nicknamed the Cochin China canal, after the breed of hens in which it seems most constant. In the one case we may suppose the canal to open after, in the other before, the closure of the posterior end of the medullary groove. If the homology is correct it may be further said that the canal is identical with Kupffer's myelo-allantoidean canal; it cannot be brought into relation with the development of the allantois, as believed by Kupffer,[10] as the allantois and enddarm are both formed before the canal appears.

The interpretation of the three canals is difficult. The middle one seems to me unquestionably the temporarily open blastopore. The third, or Braun's canal, I am inclined to regard as the blastoporic canal, which, after being closed for a while, is temporarily open a second time. The first, or Gasserian canal, is distinct from the blastoporic, as the two co-exist, and it seems desirable that this canal alone should be called *neurenteric*. As to its origin or significance nothing definite can be said, but it may be suggested that it was the excretory opening of the central canal of the spinal cord and that the cilia of the canal served to expel the fluid (compare Balfour[2]). This may have been the condition in the earliest vertebrates, and the neurenteric canal now persists as a rudimentary organ.

It seems not impossible that a persistent neurenteric canal may occur as an excessively rare anomaly in the adult.

LITERATURE.

The literature of the neurenteric canals is all comparatively recent, and is, for the most part, included in essays dealing with other embryological subjects. Great confusion has arisen from the failure to distinguish the several canals. The reader will find his way most readily by consulting first the text-books of Balfour,[2, 5] second, the article of Braun,[3] and third, Rauber's note,[12] although Rauber's terminology is eccentric and perplexing.

[1] Balfour, F. M.: On the Early Development of the Lacertilia, etc., Quart. Journ. Microsc. Sci., xix. (1879); also, in his Works, i., p. 644, with Plate 29.

[2] Balfour: Comparative Embryology, vol. ii., pp. 267–269.

[3] Braun, M.: Die Entwickelung des Wellenpapagei's; in Theil., Semper's Arbeiten, v., 205–341, Taf. x.–xiv. (a valuable but excessively diffuse article. The most important passages on the neurenteric canals are on pp. 296, 301, and 308).

[4] Durham, Herbert E.: Note on the Presence of a Neurenteric Canal in Rana, Quart. Journ. Microsc. Science, xxvi., 509–510, Pl. xxvii.

[5] Foster and Balfour: Elements of Embryology, 2d Ed. 1883.

[6] Gasser: Der Primitivstreifen bei Vogel-embryonen. Cassel, 1879.

[7] Gasser: Beitrage zur Kenntniss der Vogelkeimscheibe. His und Braune's Archiv, 1882, 359–398.

[7a] Gotte: Entwickelungsgeschichte der Unke.

[8] Heape, Walter: The early Development of the Mole (Talpa Europea). The formation of the germinal layers, and early development of the medullary groove and notochord. Quart. Journ. Microsc. Sci., xxvi., 1883, 412–452, Pl. xxviii.–xxxi.

[9] Hoffmann, C. K.: Die Bildung des Mesoderms, die Anlage der Chorda dorsalis, u. die Entwickelung des Canalis neurentericus bei Vogel-embryonen. p. 109, 5 Tafeln. Amsterdam, 1883. (Abstr. in Hoffmann u. Schwalbe's Jahresber., 1883, 442–444.)

[10] Kupffer, C.: Die Gastrulation an den Meroblastischen Eiern der Wirbelthiere und die Bedeutung des Primitivstreifs. Arch. Anat. u. Physiol., Anat. Abth., 1882, 1–30, Taf. i. iv. Fortsetzung, 139–156, Taf. viii.–ix.; 2te Fortsetzung, 1883, 1–40, Taf. i.–ii.

[11] Lieberkühn, N.: Ueber die Chorda bei Säugethieren. His und Braune's Archiv, 1882, 399–438, Taf. xx.–xxi. Fortsetzung, 1883, 435–452, Taf. xix.

[12] Rauber, A.: Noch ein Blastoporus, Zool. Anzeiger, vi., 1883, 143–147, and 165–167, cf. his earlier papers on the Blastoporic Canal, Zool. Anzeiger, ii., 1879, p. 499, and iii., 1880, p. 180.

[13] Strahl: Ueber Canalis neurentericus und Allantois bei Lacerta viridis. His u. Braune, Arch., 1883, 323–340, Taf. xiv.

Charles Sedgwick Minot.

NEURITIS. Neuritis has received various designations, depending on its cause. Thus we have traumatic, gouty, leprous, endemic, diphtheritic neuritis, etc.

Neuritis may be either simple or multiple, that is, it may be confined to one nerve area, or it may be so extensive as to involve many nerve areas.

Neuritis may be either acute or chronic. It may also be primary or secondary.

CAUSES.—Injuries of nerves are very frequently followed by inflammation.

In dislocations and fractures the nerves often suffer injury which is followed by inflammation. More frequently, however, the paralysis attending these accidents is due to more or less complete rupture of the nerve or nerves. A frequent cause of neuritis is the extension of an inflammation from a neighboring part.

In disease of the bones of the base of the skull and in meningitis we not infrequently find that the cranial nerves suffer. The intercostal nerves are often inflamed in caries of the spine and in spinal meningitis, and also in pleurisy.

The atrophy and paresis often seen in joint-diseases is due to a neuritis of the neighboring nerves. Neuritis also arises from pressure; "bed-sores" are brought about in this way.

Neuritis induced by the causes above mentioned is a secondary disease. We have a great group of causes producing primary neuritis. The most frequent is the so-called rheumatic influence.

Toxic neuritis is not uncommon. Lead, arsenic, and mercury, all induce it. Alcohol brings about a peculiar chronic form of this disease.

During the course of various chronic diseases, neuritis is not infrequent.

Gout, syphilis, cancer, leucocythæmia, diabetes, and tuberculosis induce it.

It at times follows such acute diseases as typhoid fever, measles, small-pox, dengue, and malarial fevers. It is especially frequent after diphtheritic inflammation of the pharynx.

Lastly, we have the infectious form of neuritis. Many cases of multiple neuritis are of this character.

The endemic disease known in Japan as kak-ké, and in India as beriberi, is clearly a neuritis. Neuritis is also the cause of the nervous symptoms in leprosy.

PATHOLOGICAL ANATOMY OF ACUTE NEURITIS.—When a nerve is acutely inflamed it rapidly becomes swollen, thick, and reddened.

The swelling and thickening are due to the transudation of fluid and cellular elements from the dilated vessels, while the reddening is caused by the hyperæmia. Small extravasations of blood may even be discernible with the naked eye.

Examination with the microscope shows a copious infiltration of the nerve-sheath and of the interstitial connective tissue with round cells. This cellular infiltration may be so marked as to justify the name of *suppurative neuritis*.

The amount of damage sustained by the nerve-fibres depends on (1) whether the inflammation is *parenchymatous* or *interstitial;* and (2) on the anatomical situation of the nerve. When the inflammation is confined to the sheath there is usually little or no change, unless the nerve lies in a bony canal and is subjected to direct pressure from the inflammatory exudation. When the inflammation starts in the interstitial connective tissue the nerve-fibres suffer more. They are, however, more severely damaged when the neuritis begins in their own proper structure—when, in other words, we have a parenchymatous neuritis.

The myelin breaks up into many segments, which become again subdivided, till finally it disappears altogether in some parts of the tubes, while what remains is reduced to a granular consistence. The axis cylinder is no longer to be made out. The process may go on to complete destruction of the nerve-fibre, but different fibres in the same nerve vary much as to the extent to which they are degenerated. Some appear to have almost entirely escaped, while others have been completely destroyed. Later, the stage of regeneration sets in. The nerve becomes thicker and firmer than it normally is. In the interstices between the fibres which are left there is an abundant new connective-tissue formation. In some parts of the course of the nerve this may be so abundant as to give rise to a distinct nodule, the so-called *neuritis nodosa*. Fat is frequently formed in the new connective tissue. The por-

tion of nerve peripherally situated undergoes secondary degeneration, the intensity of which entirely depends on the extent to which the inflammation has affected the trunk of the nerve.

Sometimes a neuritis may spread centrally and in this way involve adjacent nerves. As a rule, however, the inflammatory action is limited to the original seat.

The regenerative power of a nerve is very great. Even in severe cases of neuritis we not infrequently have complete restitution. A partial restitution occurs in all cases.

Chronic neuritis may be simply the continuation of an attack which commenced acutely, or it may be a chronic affection from the beginning.

In the latter case there will be wanting the hyperæmia and the cellular infiltration. The degeneration of the nerve-fibres and the increased connective-tissue formation set in from the beginning.

The interstitial tissue changes are, however, slight in comparison with the degeneration in the nerve-fibres ; so much so is this the case that it has been proposed to apply the expression *primary chronic degenerative atrophy of the nerves* to cases of chronic neuritis.

Symptoms and Course of the Different Forms of Neuritis.—Acute Simple Neuritis.—The chief symptom of a neuritis brought on by traumatism or by the extension of an inflammation from a neighboring part, etc., is *pain*. This pain is not confined to the seat of injury, but extends throughout the whole course of the nerve.

The degree of pain varies greatly. It may be slight, but more frequently it is very severe.

It is commonly of a burning character. When very intense it involves contiguous nerve districts, and at times it is felt in distant areas.

The inflamed nerve is tender on pressure.

In addition to the above direct symptoms we soon have added those brought about by interference with the function of the nerve. They are disorders of motility and sensibility, and trophic and vaso-motor changes.

The degree of motor disturbance depends on the intensity and extent of the inflammation.

It may vary from perceptible muscular weakness to the most absolute paralysis.

In all severe cases we have the reaction of degeneration. As regards the interference of the sensory functions of the nerve, it is seldom so complete as that of the motor functions. Anæsthesia, when complete, is seldom so throughout the entire paralyzed district, but is usually confined to circumscribed areas. The skin over the affected area is hyperæsthetic. Frequently, in cases where there is even complete anæsthesia, the patient complains of boring and darting pains (anæsthesia dolorosa).

The amount of muscular atrophy which attends neuritis depends on the degree and duration of the latter. If it be slight and transient there may be little or no atrophy. If, on the other hand, the inflammation be severe and chronic the degree of atrophy will be great and probably abiding.

Increased perspiration, erythema, eczema, herpes, effusion into joints, œdema, and discoloration of the skin, are not infrequent vaso-motor changes.

General febrile disturbance occurs in cases of acute neuritis, but not in the chronic form of the disease.

Multiple Neuritis.—It is only recently that the nature and importance of this disease has been recognized. Duménil was the first, in 1864, to give an accurate description of it.

Formerly it was confounded with polio-myelitis and certain forms of acute ascending paralysis.

By the term multiple neuritis is meant the implication of many nerves in inflammation.

Symptoms.—As a rule, the disease sets in acutely, with the general symptoms of an acute infectious disease. Not infrequently we have albuminuria (febrile) and swelling of the spleen, symptoms which indicate strongly its infectious nature.

The mode of onset may be subacute. It is very rare for it to be of a chronic character.

The first definite symptoms are pains in the lumbar regions and extremities. They are of a tearing and burning character. They generally follow the course of the principal nerve-trunks.

Coincidently with the pains, and sometimes even earlier, there is a complaint of "pins and needles," or numbness in the feet and hands.

There is great tenderness of the skin, of the nerve-trunks, and especially of the muscles.

In marked contrast to the subjective sensory complaints are the objective changes in sensation. Complete anæsthesia is extremely seldom present. Minor degrees, however, are frequently noticed.

The disease is essentially one of the motor nerves. Very soon after the appearance of the initial symptoms, weakness of the limbs is complained of. It is generally most marked in the lower extremities. It may be confined to the lower extremities, but more frequently it involves both upper and lower. The paresis soon develops into paralysis.

The extensors of the hands and the flexors of the feet suffer most. It is very unusual to find absolute paralysis of both flexors and extensors.

The cerebral and bulbar nerves in the great majority of cases escape. The vagus is more frequently involved than other cranial nerves. The increased frequency of pulse and the vocal cord paralysis, which are sometimes present, are explained in this way.

The reflexes (tendinous and cutaneous) are either lessened or entirely absent. The nerves and muscles, a few days after the commencement of the disease, present signs of diminished electric contractility, which soon passes into the typical and pronounced reaction of degeneration. The paralyzed muscles soon atrophy. Trophic changes also occur in the skin, nails, and hair. Increased perspiration and œdema are frequently present.

The innervation of the bladder and rectum is not disturbed.

Course and Duration.—In the severest cases a fatal result may occur in from a week to ten days, the cause of death being due in these cases to paralysis of the inspiratory muscles—the diaphragm and the intercostals.

In cases of less intensity a fatal ending may be brought about after several weeks by the exhaustion of the continuous pain and the bed-sores.

It is difficult to give even an approximate estimate of the percentage of fatal cases. In the milder varieties the symptoms slowly increase for a period of five or six weeks, then gradually subside, complete recovery occurring in the course of a few months.

Not infrequently the course of the disease is a very chronic one, with occasional acute exacerbations. Here we may have a fatal result, but more commonly complete or partial recovery occurs.

Great improvement may take place even after the disease has lasted a year. Relapses are not uncommon.

Recovery may be imperfect, by reason of the contracture of the opposed muscles.

Diagnosis.—In typical cases there ought to be no difficulty in the diagnosis. The acute onset, with marked disturbances of sensibility and tenderness of the nerves and muscles ; the general hyperæsthesia of the skin ; the rapid and pronounced paralysis, with atrophy and the reaction of degeneration ; the loss of the tendinous and cutaneous reflexes, all point to the peripheral nature of the disease.

The disease most liable to be confounded with it is acute polio-myelitis. In the latter we never have the severe and long-continued pains which are so characteristic of neuritis. In polio-myelitis tenderness of the nerves and muscles on pressure is not present, and there never are any anæsthetic patches.

In neuritis the paralysis is wide-spread and symmetrical. In polio-myelitis the paralysis is unequal in extent and degree.

Symptoms common to both diseases are the acute pyrexial onset, rapid paralysis with atrophy and reaction of degeneration, together with a tendency to the spontaneous recovery of the least affected parts.

There can be no great difficulty in diagnosing multiple neuritis from the acute ascending paralysis of Landry,

for in the latter there is no disturbance of general sensibility, neither is there any change in the electrical reaction and nutrition of the muscles. From compression myelitis the distinction would be made by the presence of bladder and rectal disturbances of innervation, by acute bed-sores, and by increase of the reflexes in the parts below the compression.

In pachymeningitis damaging the nerve-roots we have both paralysis and wasting, and occasionally also anæsthesia. But in this condition we would have in addition certain definite spinal symptoms, such as stiffness in the neck, pain in the back, increased by movement, and twitching of the muscles of the extremities. There would, however, be no tenderness on pressing the nerve-trunks or muscles. The upper extremities would be mainly involved and, what is of importance, the whole course of the nerves would suffer, and not principally their periphery, as we find in neuritis.

Prognosis.—During the very acute stage the prognosis is necessarily very doubtful, for at any time the innervation of the respiratory muscles may be so interfered with that death may happen suddenly. When the upper part of the limbs and trunk is involved this danger is all the greater.

When the acute stage has passed the prognosis is good, for the great majority of cases end in either complete or incomplete recovery. No matter how great and extensive the paralysis may be, recovery may be perfect, even after many months. The presence of grave organic disease naturally intensifies the danger.

Treatment.—During the acute stage salicylic acid is well spoken of, in doses of one gramme (16 grains) three or four times daily. It is given on the principle that the neuritis is caused by some poisonous blood state. If given at all it should be given freely, until the full physiological effects are induced. This is the only remedy that has been recommended as having any influence over the course of multiple neuritis.

The symptomatic treatment of the disease is very important. Pain is to be relieved as much as possible. Our means for this end are not different from those usually employed.

There is nothing special about either the dietetic or the hygienic treatment.

After the disease has passed into a subacute or chronic stage it is important that the position of the limbs should be closely watched, otherwise troublesome contractures will result. The patient should be encouraged to move about, and passive motion should be employed. At this period benefit will also be derived from the use of the slowly interrupted galvanic current.

Alcoholic Neuritis.—Synonyms: Polyneuritis Potatorum, Pseudo-tabes, Ataxia of Drunkards. For a long time it has been known that certain peculiar chronic nervous symptoms follow occasionally the immoderate use of alcoholic stimulants, especially of ardent spirits.

Cases of paraplegia of alcoholic origin have been frequently reported. It is only quite recently, however, that the true nature of this loss of power of the lower extremities has been recognized. In the majority of cases it is undoubtedly due to a peripheral lesion—a multiple neuritis of the nerves of the lower limbs. It cannot be denied that a paraplegia may be due to a *meningo-myelitis* from alcohol.

There are two distinct clinical varieties of alcoholic neuritis, the paralytic and the ataxic. It is seldom that these varieties are seen in their purity; nearly always there is paresis in the ataxic form and ataxia in the paralytic cases.

Ataxic Form.—This represents a milder type. The first symptom is usually severe pains affecting any or all of the extremities. They are more frequent in the lower extremities. They are of a lancinating or shooting character. Anæsthetic spots in the affected extremities are frequently to be made out. The muscles are nearly always hyperæsthetic, this being one of the most constant features of alcoholic neuritis.

Ataxia sets in after a considerable time, and is usually of a very pronounced character. It may affect all the extremities, but it is more common and more marked in the lower. There is an absence of the deep reflexes and frequently, also, of the superficial. When the latter are present the response is slow. Bladder, rectal, and eye symptoms are usually absent.

Weakness of the muscles is complained of, but this seldom reaches to more than a slight paresis. Trophic and vaso-motor changes are not present.

In the mixed forms we have a combination of paresis or paralysis with ataxia.

Paralytic Form.—In this variety we have the same sensory symptoms at the beginning, followed sooner or later by diffuse paralysis and atrophy. Dreschfeld thinks it probable that the paralytic stage is preceded by an ataxic one in these cases.

The paralysis and atrophy affect chiefly the extensors of the fingers and toes. The paralyzed muscles present the complete reaction of degeneration.

The course of the disease is very chronic. It usually, however, ends in complete recovery, if the cause is no longer in operation. It may end in incomplete recovery from changes in the antagonistic muscles. Contractures of the flexors of the knee may be permanent, and so cripple the patient for life.

When death takes place it is generally due to involvement of either the phrenic or the vagus nerve in the morbid process. It does not, however, necessarily follow that death takes place in all cases where either one or both of these nerves are affected. The writer has seen recovery follow where there was the strongest evidence pointing to neuritis of the vagus and phrenic in addition to a general neuritis of the nerves of the extremities.

Diagnosis of Alcoholic Neuritis.—A careful examination of the paralytic form will always lead to a correct diagnosis, but there may be difficulty in coming to a conclusion in the ataxic variety. The symptoms so closely resemble those of pure tabes dorsalis that a correct diagnosis for a time may be impossible. In alcoholic ataxia we seldom have the loss of the reflex contraction of the pupil (Argyll-Robertson phenomenon), the "band-sensation," or bladder and rectal paresis or incontinence. Further, the "lightning pains" of true locomotor ataxia are different from those of ataxic neuritis ("false ataxia"). In the latter they have a continuous character, and do not cease for weeks or months, as is the rule in tabes dorsalis.

In alcoholic neuritis we frequently have a peculiar form of delirium, which is never seen in tabes dorsalis. The patient has delusions of a remarkable character. He imagines often that he has been away, and will recite, with great gravity, conversations he supposes he has had with people, while all the time he has never left his bed. The delirium at times is not different from that ordinarily seen in alcoholism without neuritis.

In both alcoholic neuritis and tabes dorsalis joint affections are occasionally noticed, but they differ entirely in their character. In the former the joint changes are of an acute character, and closely resemble those seen in acute rheumatism. In fact, it is quite possible to mistake these two diseases. In tabes dorsalis, on the other hand, the joint affection is chronic in its onset and course, and is, above all, of a painless character. In neither affection is the true nature of the joint changes understood.

Complications.—Spinal meningitis and myelitis occur occasionally during the course of neuritis alcoholica. The writer has had recently under his care a case where, in addition to these spinal changes, there was also a cerebral meningitis. These complications are due to the original cause, and not to an extension of the morbid process. They, of course, greatly add to the gravity of the prognosis. In the case referred to, however, recovery followed.

It is surprising from what apparently hopeless conditions patients may recover completely. There is much in the action of alcohol on the nervous system that we are still ignorant of.

Treatment.—Of course, the first and important part of the treatment consists in the withdrawal of all stimulants. Strychnine is said to have some influence in

counteracting the effects of alcohol on the nervous system. How it acts is not known. It has an undoubted influence for good in some allied nervous affections, as in lead and tobacco amblyopia. It should therefore be given.

For the paresis or paralysis, electricity should be employed.

There is nothing special in the fulfilment of the remaining symptomatic indications. *James Stewart.*

NEUROMA. The neuroma is a tumor composed of nervous tissue, or into whose composition nervous tissue largely enters. The name neuroma formerly had a much wider signification than it has now, and was used to include all tumors seated along the course of nerves. Odier introduced the term at the beginning of this century, as descriptive of tumors which originated in the substance of a nerve. He regarded the tumor as an aneurism of the nerve, the fibres of which were pressed apart by a sort of material which developed between them. Most of these tumors which develop along the trunks of large nerves are myxomas or fibromas, and the nerve takes no part in the formation of the tumor, but simply runs over, or at most through, the growth. The true neuroma, consisting of nerve tissue, is to be distinguished from these, although the word is still rather loosely used by surgeons to include all manner of growths along the nerves.

The neuroma may contain either of the two chief tissues of the nervous system, either ganglion-cells or nerve-fibres may enter into its composition. In the former case it is called ganglion neuroma, or *neuroma cellulaire*, and in the latter fibrillar neuroma, *neuroma fibrillaire*. The fibrillar neuromas may again be divided, according to the nature of the fibres, into those composed of medullated nerve-fibres, *neuroma myelenicum*, and those composed of non-medullated fibres similar to the sympathetic system, *neuroma amyelenicum*. Various other names, descriptive of some peculiarity of structure or situation, have been given the tumor, as *neuroma centrale*, when the seat of the tumor is in the central nervous system; *neuroma peripliericum*, when seated on the nerve-trunks; *neuroma terminale*, when the terminal apparatus of the nerve is involved; *neuroma multiplex*, when there are numerous such tumors present; *neuroma telangiectodes*, etc.

Of especial interest are the peculiar tumors which William Wood described in 1832 as painful tubercles of the skin. These are small subcutaneous tumors, which are freely movable beneath the skin, which is but slightly elevated over the tumor. They are especially characterized by the pain which accompanies them. This pain is intermittent, and of a peculiar, intense, lancinating character. It is often coincident with changes in the weather, especially with cold, moist weather, and is often most severe at the menstrual period. It has long been a question whether or not these tumors should be reckoned with the neuromas. Their composition varies in different cases. Vallender investigated such a tumor, which he extirpated from the knee, and found it to be composed of spindle-cells and dense connective tissue, in which bundles of medullated nerve-fibres were contained. In some cases the outer part of the growth is composed of concentric layers of dense connective tissue. In a case examined by Axmann a tumor the size of a pea was extirpated from the elbow, and he regarded the whole as identical with an enlarged Pacinian body. The tumor consisted of five lamellæ of fibrous tissue, which lay over one another and were partially grown together. A nerve-tube entered these lamellæ, but could be followed only through the outermost layers. In a case investigated by Virchow a nerve entered and emerged from the tumor, and the whole mass was composed principally of amyelenic nerve-fibres. Virchow proposes to separate these from the others under the name of *neuromata dolorosa*. In other cases examined the growth has been found to be composed of various sorts of tissue, and nerves were found in some cases, in others not. Hoggan and wife found in the case examined by them an adenoma of the sweat-glands, in which they could not positively make out the presence of nerve-fibres. In all cases the vessels have been strongly developed, in some the growth has almost the appearance of a cirsoid aneurism. Recently Chaudelux has made a careful histological study of these tumors. He was able to show the presence of abundant nerve-fibres in every case, by using gold chloride, and examining the tumors fresh before they had been hardened in any reagents. Some of the nerve-fibres which the tumors contained were the ordinary medullated nerve-fibres, but the most of them were non-medullated fibres, similar to the terminal nerve-fibres. These were present in the tumor in such numbers that they made a very considerable part of the growth. The pain is easily explained by the compression which is exerted on these fibres by any cause which alters the consistency or tension of the growth, as temporary hyperæmia, etc. In all the cases examined by him, in addition to the nerves, various other tissues were present, and in every case there was a considerable number of blood-vessels.

The pure neuromata may be free from pain, or only begin to be painful when they have existed for a long time. They generally originate in the large, deep-lying nerve-trunks, which are not only not exposed to any mechanical or thermal injury, but contain very few sensitive fibres. The tumors composed of medullated nerve-fibres are white or grayish-white, and those composed of non-medullated fibres are gray or yellowish. Both of the tumors are rather firm, and feel very much like fibromas. Of the two the amyelenic neuroma is the most frequent. The non-medullated fibrous neuroma, when examined under the microscope, appears similar to the fibroma or leiomyoma. When examined in acetic acid, or stained with a reagent which only stains the nuclei, one sees only a large number of long nuclei imbedded in a firm fibrillar tissue. When examined in this way it may readily be mistaken for a myoma. If the sections are treated with nitric acid, or with caustic potash, and the connective tissue dissolved or rendered transparent, it will be found that each nucleus is connected with a long fibre. This is better seen in fresh sections which have been stained for a long time in borax carmine, and then examined in acid glycerine. In sections in which a bundle of nerve-fibres has been cut longitudinally there will be no difficulty in recognizing their true nature, if they are treated in this way. The plexiform neuroma, or, as Paul Bruns has named it, the Ranken-neuroma, *neuroma cirsoideum*, forms one of the divisions of the fibrillar neuroma. This is formed by a convolution of cylindrical solid cords, which are wound and twisted in every direction, and form irregular lumps, which are imbedded in connective tissue. The skin over the tumor is smooth, pigmented, and contains large, thick hairs and enlarged hair-follicles. The whole resembles a large, rough, dependent fold of the skin. It may be as large as the fist, and is sometimes very painful. It is generally congenital, and has most connection with elephantiasis mollis congenita, but has also been seen in acquired elephantiasis of the prepuce. The brown pigmentation of the skin over the growth is produced, according to Winniwarter, by the closure of the capillaries in consequence of proliferation of their nuclei. Thrombi are then produced, the pigment from which stains the cells of the rete Malpighii. Winniwarter saw single nodules of the plexiform neuroma change into sarcoma. It is often combined with multiple neuroma, and, according to Czerny and Winniwarter, it is secondary to disease of the trophic nerves of the part.

The multiple neuromata form an important group of these tumors. In these Virchow distinguishes, with Lebert, a multiplicity of three kinds. Nodules may form on the same nerve in several places, giving it the appearance of a rosary. Nodules may form on all the branches of the same nerve. Nodules may form on the nerves of an individual in different localities; there have been a number of observations where neuromas were found on almost all the branches of the spinal nerves, and on many of the sympathetic nerves. Many of the cases of multiple neuromata which are cited do not belong to this class of tumors at all. Virchow is inclined to believe that the

tumors in the first two classes certainly belong to the neuromas, and most of those in the third class. They are most frequently amyelenic. In many cases the tumors appear to have been congenital and inherited. The first observations on the subject are those from Schiffner and concerned two brothers, both of whom were idiotic. Several cases have been seen in regions where cretinism is endemic. Hitchcock reports a case where multiple neuromata appeared in a mother and her two daughters. Other observers do not agree with Virchow, that the third class are true neuromas. In a case described by Prudden over one thousand tumors were observed on the different nerves. Not only were the spinal nerves affected, but also the cerebral and sympathetic nerves. The sheaths of many of the nerves were very much thickened. Both macroscopically and on microscopic examination an increase of both the interfascicular and the perifascicular connective tissue could be made out. This growth of connective tissue in some cases was similar to a myxoma, in others to a fibroma. The nerve-fibres were of normal size, and a new formation of them was not observed. In one nodule which was seated on a branch of the lumbar plexus, ganglion cells, similar to those of the sympathetic ganglia, were found. Genersich and Takacs hold the same views with reference to these tumors.

Fig. 2491.—Amputation Neuroma. (Virchow.)

The traumatic neuromas arise in consequence of various injuries to nerves. They represent attempts at nerve regeneration, which sometimes exceed the necessary growth. The amputation neuroma is the best example of such a tumor formation, in consequence of regenerative processes of the nerves. When nerves, especially the larger ones, are cut through and no possibility is given for the cut ends to be united by cicatricial tissue a tumor is formed on the stump of the nerve. This growth of the nerve should not be considered among the tumors. They are so bound up in the soft parts of the amputation stump that it is often almost impossible to prepare them out from the remainder of the tissue. The single nodules so formed vary considerably in size. This depends, up to a certain point, on the size of the nerve which was cut. As a rule, the largest of these tumors are found on the large nerves of the body, especially on the sciatic and large brachial nerves. It cannot be said that the degree of irritation to which the cut ends of the nerves are subjected exercises any great influence. The tumors are found just as often in stumps of the arm as in those of the leg, although the irritation to which the leg stump is subjected, by the pressure of the artificial leg, is much greater than that to which the arm is exposed. The growth can be felt in the cicatrix as a hard, firm body, making almost the impression as if a shot were imbedded in the tissue. In some cases it is extremely sensitive, and the seat of neuralgic pains, which are especially severe in changes of the weather. The cause of this varying degree of pain in these tumors is due to the varying vascularity in the different cases. All movements which produce temporary congestion produce pain by increased pressure on the nerves. On microscopic examination the tumor is found to be made up of innumerable bundles of nerve-fibres, which run through the mass in every direction, twisting and twining through it. Virchow supposes also that neuromata may arise in the neighborhood of chronic inflammations, and cites as an example a case in which an arm was amputated on account of caries of the wrist joint, and some distance above the joint a tumor was found on the median nerve. The tumor was in great extent composed of medullated nerve-fibres. Cases where neuromata are found in elephantiasis and other chronic affections belong to the same category.

Fibrillar neuromata are also found in the vertebral canal. These, of course, have a degree of importance differing according to their situation, those high up in the canal being most dangerous. Small fusiform swellings are often found on the nerves in the cauda equina, but generally these are not neuromas but small fibromas. Neuromata are also found on the cranial nerves of special sense. They are most frequent on the acoustic nerve. In many cases it is difficult to say whether the tumor is seated on the acoustic or facial nerve. The consistency of these tumors varies; in some cases they are firm and hard, almost like cartilage, and in others they are soft and gelatinous. Sometimes cysts or small hæmorrhages are found in them. They may be seated on the nerve close to the brain, or near the foramen of the nerve, and in these different places they produce different symptoms. Deafness is generally present and sometimes facial paralysis. The nodules may reach the size of a cherry or plum, and they always exert considerable pressure on neighboring parts. They may be confounded with psammoma of the dura mater, which also often appear in such places.

Fig. 2492.—Recurrent Amyelenic Neuroma of the Fore arm. (Virchow: Geschwulstlehre.)

The cellular neuromas are most often found in the lateral ventricles of the brain outside of the corpus striatum and optic thalamus. They are also sometimes seen as small gray masses enclosed in the white matter of the brain. These may be confounded with the small masses of gray matter enclosed in white, which are often seen in sections made across the brain and which simply represent the end of a sulcus. Virchow has included with the central neuromata many cases of encephalocele and hydrencephalocele which properly belong to the malformations. Besides the cellular neuromata, which have been spoken of, neuromata may be found in other tumors, especially the teratomata. The writer examined a case a few years ago in which a large tumor was found in each ovary, and in which, along with skin and its appendages,

muscle, and various other tissues, there was a good deal of nervous tissue present, partly in the shape of nerve-fibres, partly as large collections of ganglion cells. The formation of cellular neuromata along the nerves is very rare, if it ever takes place. Sometimes, however, in certain nerves the ganglia vary much in size. Weichselbaum has reported a case in which a nodule in one of the suprarenal capsules was found to be principally composed of ganglion cells.

The neuromata are in general non-malignant tumors, though they may prove fatal from their situation and numbers. A few cases have been known where they returned after removal, ulcerated, and grew with great rapidity. The accompanying figure, taken from Virchow, shows a large ulcerating tumor, which appeared at the site of the excision of an amyelenic neuroma. The tumor recurred five times after excision, grew with great rapidity, and finally other nodules formed on the neighboring nerves. The arm was then amputated and no return followed for five months, at which time the man died of a pneumonia. In some cases after the removal of neuromata, sarcomata have appeared in the same situation. *W. T. Councilman.*

NEUROMA OF THE SKIN, PAINFUL. Under this designation Duhring has described a form of neuroma which, although not differing in any anatomical essential from the other forms of neuroma, yet presents clinical appearances which would seem to justify its separate description as a disease of the skin. In the case described by Duhring, which was also seen by the writer, the disease appeared over the arm and shoulder, in the form of numerous firm, flattened tubercles, the size of a small split pea, occupying the left scapular region, shoulder, and outer surface of the arm, as far down as the elbow. Over the shoulder and arm they were closely packed together, the surface presenting a mass of firm, nodular tissue. They were immovable and firmly incorporated with the skin, and extended into the subcutaneous connective tissue. They were irregularly disseminated, and occupied no nerve-tract. About the scapular region and down the arm near the elbow they were more scattered and discrete, the skin between them being normal. They were pinkish or purplish-pink in color, the more recent isolated formations being of a pale rose tint, or the color of normal skin. The color of the diseased surface, as a whole, varied according to the position of the limb and the presence or absence of pain. The surface was warmer than the adjacent skin, and during an attack of pain became hot and violaceous in color. The surface was slightly scaly.

A case reported later by Kosinski is given in the last edition of Duhring's "Handbook." Here the affection occupied the posterior and outer sides of the right thigh, as far down as the lower third, and a portion of the buttock. The appearance and character of the lesions were essentially identical with those observed in Duhring's case.

A third case was more recently reported by Arnozan and Vaillard. Here the lesions were found grouped in a mass, and also disseminated over the skin of the right arm, neck, and clavicular region, with a few scattered lesions, chiefly about the right side of the trunk. The more recent lesions were small, firm, papular growths, the size of a lentil, and of a rose tint which disappeared under pressure. The larger lesions were more elevated above the surface, less sharply defined, and of a more dusky red. In their grouped patches the lesions seemed larger and massed together, and appeared to have a rough, indurated, irregular surface.

In both Duhring's case and the one last quoted, paroxysmal pain of a marked character formed a striking feature of the disease. In both cases this did not begin to show itself until three years after the first appearance of the tubercles. In Duhring's case the pain is described as excruciatingly violent, shooting down the arm as far as the knuckles, across the chest, and up the side of the neck and head, the paroxysms usually lasting an hour or longer. The exciting causes were movement of the affected part, exposure to cold air, and mental worry or excitement. Any decided change to bad weather was accompanied by an attack, and there was greater immunity from pain in the summer than in the winter, or during a rainy or snowy season.

In the case reported by Arnozan and Vaillard the pain was most severe about the forearm, sometimes radiating thence over the entire member. Pressure, a blow, rubbing, or even at times the lightest contact, as of the clothing, for example, were sufficient to determine the neuralgic attacks. Heat and cold were particularly obnoxious, so that the patient could not work in the open air in midwinter or in midsummer. When the patient's clothing was removed for examination she suffered much pain, and a fragment of ice kept in contact for a short time with one of the tumors on the forearm made the patient scream with pain. Paroxysms of spontaneous pain by night as well as by day were also a feature of this case. These began invariably in some single tumor upon the forearm and radiated from that point in all directions, but particularly toward the fingers; occasionally upward as far as the neck. The pain was often deep and piercing, sometimes as though the arm were plunged in boiling water, at other times as though the tissues were being torn.

At the beginning of the neuralgic paroxysms the tumors were pale, but after a time they resumed their customary dusky tint. In Duhring's case increased heat and redness were noted, as above mentioned, but the precursory pallor was not observed.

Kosinski's case, as quoted by Duhring, presented the same general symptoms as the two above given, excepting that the affected region occupied the posterior and outer sides of the right thigh.

In none of these three cases was internal or external treatment of the least avail in relieving the severe pain. The case of Arnozan and Vaillard disappeared from observation. Duhring's case had an inch of the brachial plexus exsected, but with only temporary relief, and the unhappy sufferer lingered on for several years until death ensued from some intercurrent disorder. Kosinski's case had a happier termination. A portion of the small sciatic nerve, an inch in length, was exsected, with the result of affording immediate relief, and four months later the lesions had nearly disappeared and were entirely painless.

Microscopic examination of the tumors, which was made in each of these cases, showed them to be composed of non-medullated nerve-fibres and connective tissue in varying proportions, and in the case of Arnozan and Vaillard of smooth muscular fibres also. They were, in fact, essentially fibromata, at least as regarded the older lesions (see Molluscum Fibrosum).

Painful neuroma of the skin is to be distinguished from painful subcutaneous tubercle which is single and movable under the skin, not embedded in it, and the multiple painless neuroma described by various authors. For further detail regarding the pathology of neuromata of all kinds the reader may consult the article Neuroma above, and also the works referred to below.

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Arthur Van Harlingen.

NEUROMIMESIS is a term devised by Sir James Paget[1] to designate a class of cases characterized by many or all of the symptoms of a real pathological condition, but where there is only a simulation of a true lesion or deformity.

This condition was first mentioned by Sir Benjamin

Brodie,[2] and to him must be given the credit of clearly describing and bringing before the profession these local manifestations of a general disturbance of the nervous system. These cases have received attention from various writers, under different appellations, most of them considering them as having a common origin in hysteria; and it is by no means unusual to read of "hysterical joints or spines," or "hysterical contractions" productive of various deformities; while the terms "pseudo-arthropathies," "mock disease," "joint neuroses," have been used to describe the same affection.

In view of the importance of the subject, and notwithstanding the fact that much attention has been given to it in the more recent monographic literature, it is surprising that this class of cases has not received more special consideration in those works which treat exclusively of joint diseases and deformities. Thus Hueter,[3] in his "Gelenkkrankheiten," dismisses the subject with a few remarks, which tend to throw a doubt on the existence of any such class of cases; while neither Sayre[4] nor Bauer[5] have seen fit to mention the subject in their works on orthopædic surgery. Exception to this must be made in the case of Barwell,[6] who, in his "Treatise on Diseases of Joints," has devoted a chapter to "Hysteric Pseudo-disease of Joints," giving very valuable information on the subject.

While there is no form of disease which cannot be simulated by the condition known as hysteria, it will be the object here to consider only those neuromimeses involving the articulations, the spine, and the more frequent deformities, such as club-foot and lateral curvature of the spine.

Etiology.—With the exception of extreme infancy and old age, no period of life is exempt from participation in these troubles, although it has been stated that the age of puberty is the most frequent time for their manifestation; and while a marked preponderance of the cases occur in females, they are by no means confined exclusively to them, cases not infrequently occurring in males.

The condition of life, according to Brodie, has a marked etiological bearing, and he has made the following remarkable statement: "I do not hesitate to declare that, among the higher classes of society, at least four-fifths of the female patients who are commonly supposed to labor under disease of the joints, labor under hysteria, and nothing else;" and this statement has been corroborated by Esmarch.

While it cannot be denied that luxurious living, the dissipations of society, and the incidents of fashionable life are conducive to a lowering of the general health, and thus, where the neurotic element is present, to a development of hysteria, it would seem that the proportion, as stated by Brodie, is too high. There can hardly be a doubt that the opposite condition of poverty, implying, as it does, want of proper food, and poor hygienic surroundings, in conjunction with hereditary or acquired nervous disease, is just as liable to give rise to neuromimetic troubles.

Indeed, Paget states that some of the worst of all kinds of these cases occur in poor people; and Skey,[7] in speaking of hysteria, remarks that it "includes a large proportion of the lower classes;" and furthermore, in writing of its local effects, says: "In reference to spinal affections in young persons, I unhesitatingly assert that the real disease is not found in a greater proportion than one case in twenty, and even this is a liberal allotment."

The truth of the matter probably lies in the fact, as stated by Shaffer,[8] "that neuromimetic joints and spines, and more particularly the latter, are very frequent both in the upper and lower classes, and especially at that age when hysteria is most likely to develop."

The immediate production of these pseudo-diseases may take place in one of two ways—the first, by an impression on the nervous system through the medium of the emotions, such as disappointment, mental anxiety, long-continued illness, etc., and the manner of action in these cases is well expressed by Brodie as follows: "As the commonest event may prove a source of annoyance to an irritable mind, so will nerves which have been kept for some time in a state of irritation transmit every impression that is made on them to the brain with a disagreeable or painful sensation superadded to it; in other words, the part affected will be tender to the touch, and more than this, the tenderness will be followed by increased vascularity, by a slight degree of swelling, by actual inflammation. I do not mean to assert that any very active inflammation will be established, such as will end in suppuration and abscess, or ulcer; it will be moderate in degree, but it will be inflammation nevertheless, and marked by the usual symptoms."

The other immediate causation consists of a traumatism acting directly on the parts. Thus, when a moderate or severe injury has been received by a neurotic individual, it may be followed by a train of symptoms which would lead to a condition very closely resembling true disease, and which, by their persistence and chronicity, give the greatest trouble in diagnosis. The question of diathesis as an etiological factor is of some importance to us in estimating the cause in a given case. In all of these cases there is a decided abnormal condition of the functional nervous system, and while it is not always easy to trace this directly to the individual suffering from the trouble, it will usually be found that the family history gives evidences of the nervous disease in the form of hysteria, insanity, chorea, epilepsy, etc.

In conjunction, however, with nervous disturbances, we may have a tuberculous, gouty, or scrofulous diathesis to deal with, and from this it is evident that the existence of the conditions most favorable for the production of neuromimesis does not preclude the presence of a real trouble of the articulations or spine; and this fact should always be borne in mind in estimating constitutional causes for either true or false disease.

Association with cases of true deformity or disease is another mode of origin, and these are the only cases in which it can be said that there is an absolute "mimicry." This unconscious imitation is not of frequent occurrence, yet cases do undoubtedly arise by this direct contact, as shown by instances of it reported by such competent observers as Paget, who reports the case of two brothers, one with true hip-joint disease, the other with a neuromimetic hip; and Shaffer in the cases of two sisters, one of whom had passed through the stages of a chronic suppurative coxitis, the other afterward developing symptoms very closely resembling true hip-joint disease.

Lastly, there are instances where it is impossible to find any apparent cause, the neuropathy developing suddenly and seemingly spontaneously, being often the first evidence of the disturbed balance between voluntary and involuntary power, eventually ending in well-marked hysteria.

Relative Frequency.—The only statistical information as yet collected on the relative frequency of the neuromimeses pertains only to the articulations, and was collected by Esmarch.

In eighty cases, fifty-one of which were personally seen by him, thirty-eight occurred in the knee-joint, eighteen in the hip-joint, eight in the articulations of the hand, seven in the foot, and four in the shoulder-joint.

It will be seen that the relative frequency follows very closely that which obtains in the real joint-diseases. It would seem, however, from the remarks of Brodie and Skey, as well as the observations of others, that the spine is by far the most frequent seat of a neuromimesis.

Symptoms.—In order to be able to discriminate between the true and false, or neuromimetic, forms of joint-disease, it is manifest that a thorough knowledge of the history, symptoms, and course of the various forms of real articular disease is absolutely necessary. This knowledge is the more imperative, as there is no symptom of true articular trouble which may not be present in the neuromimetic condition. In order, therefore, to simplify our study of the false forms of disease, we shall give the characteristics of the prominent symptoms, beginning with pain.

Pain is a constant factor in all cases of neuromimesis, sensation being always exalted, and the nature of the pain is of great value in diagnosis. Thus it is always superficial, being produced by the slightest pressure, and

not always at the seat of the disease; being in fact a hyperæsthesia of the external tissues rather than the deep-seated pain of true joint-disease. Deep pressure rather modifies than increases it, and all those movements of the joint, such as concussion, rotation, etc., which in true disease give rise to the most excruciating agony, do not seem to increase the pain when dealing with the false variety. Another prominent feature is its wandering character, in the simulated disease of the knee-joint, for instance, going up to the hip and down to the foot, while in that of the hip-joint it is complained of in the buttocks, inner side of thigh, or radiating to the spine. These pains are described as pulling, tearing, boring, or cutting in character, and in some, as mentioned by Esmarch,[9] as "beating" and synchronous with the pulse, such as is experienced in an inflamed finger. The pain, while generally worse at night, has not the "starting" character so often found in true joint-disease, and which gives rise to the so-called "osteitic" cry, allowing the sufferer no sleep. On the contrary, when the patient is once asleep this symptom of the false disease disappears.

Another important point is that the attention of the patient being diverted from the diseased part, the pain disappears, and in none of these cases do we find that peculiar look of long-continued suffering so expressive, and in itself so suggestive, of chronic disease.

Limp.—As in real, so in the neuromimetic, forms of articular disease, the first symptom which may call attention to the patient is the appearance of a limp. This, while a symptom of much importance in the real disease as showing joint disability, and being of itself an important symptom when inflammation is present, has no such significance in the false disease. In the true joint-disease, the patient endeavors as much as possible to conceal his lameness, while in the false disease, as in the case of the pain, he exaggerates it constantly, changes his step so as to disclose his lameness more plainly, and renders it out of all proportion to the co-existing objective symptoms, although at times, when he is not observed, his lameness disappears entirely.

Motion of the articulation, the subject of any real inflammatory disease involving the bone is always attended by limitation, and with this we invariably obtain *reflex muscular spasm*. In the neuromimesis of joint-disease, while we have the limited motion, we never get this reflex spasm, and this constitutes one of the most valuable aids to diagnosis; and while no amount of pressure which can be brought to bear safely in the real variety of the disease, is sufficient to overcome the spasm, in the false variety continuous pressure, attention being diverted, easily overcomes the limited motion, while the position taken by the limb is easily rectified, or it of itself assumes different positions. In the true form of disease the position of the limb is fixed, only changing at long intervals from inter-articular progression of the inflammation.

Muscular atrophy is always attendant on true disease of the articulations, and is a constant factor, increasing with its progress and not being due to any appliances used in treatment—being in fact, as demonstrated by Shaffer[10] and Valtat,[11] a true atrophy depending on disease of the bone, and showing a marked reduction of the electro-motor contractility when tested by the faradic current. In the neuromimetic variety the atrophy is always slight, and in no way proportionate to the length of time during which the disease has lasted, and is either due to disuse of the part, or to the application of external agents, while the muscles give a normal reaction to the electric stimulus.

Shortening in real disease is always due to bone changes, and, depending on the nature of the disease, may be rapid or slow, most cases showing this change at a comparatively early period. The shortening attendant upon neuromimesis is always apparent, exception being made in those cases where congenital differences exist. Deformity may, however, be simulated in these cases by changes of posture, necessitating very careful adjustment of the pelvis and measurement of the limb. Swelling from inter-articular effusion is an almost constant symptom of true joint-disease, and this may be very closely simulated in the false variety. There is, however, a characteristic appearance to the deep-seated swelling of chronic joint-disease, which is not seen in the neuromimesis. In the former the tissues are of a dull white color, with the distended veins showing clearly on the surface, and having a feeling of deep-seated fluctuation. After long-continued counter-irritation by the use of iodine, ice, blisters, or other means, a similar appearance may be given to the neuromimetic joint, but the swelling is always superficial, and with a withdrawal of the irritation soon disappears. Abscess so frequent a result of real disease, is never a consequence of the false condition, although Brodie mentions instances where urticarial swellings frequently appeared, giving rise to some doubts as to the nature of the effusion.

The following table will give succinctly some of the more prominent differential points in the diagnosis of true and false joint-disease:

True Variety.	Neuromimetic Variety.
Pain.—Deep—produced by deep pressure, concussion, or rubbing of joint surfaces—always found at fixed spots. "Starting" at night. Not relieved by sleep.	Superficial—produced by slight pressure, modified by deep pressure—wandering in character. No "starting" pains; ceases entirely in sleep. Ceases when attention is withdrawn from diseased part.
Limp.—Always constant in character.	Always exaggerated, and changes in character. At times disappears entirely.
Motion.—Limited, and always attended by reflex muscular spasm when bone-disease is present. Not overcome by pressure. Position of limb fixed.	Limited, but unaccompanied by spasm. Overcome by continuous pressure, attention being distracted. Position changes, or is easily rectified.
Atrophy.—Marked and always present. Muscles show marked reduction of contractility to faradic current.	Slight, or wanting, and not in proportion to length of time of disease. Normal degree of muscular contractility in response to faradic current.
Shortening.—Real, due to bone changes.	Apparent, due to posture or, rarely, is congenital.
Abscess.—Frequent.	Never occurs.

Of the constitutional symptoms, as observed in the true and false forms of joint-disease, those which relate to the temperature, local and general, should be carefully studied. The presence of heat in a joint is one of the most positive signs of inflammation occurring in or about it, and Paget states that it may be accepted as positive that a hot joint is an inflamed one. This, when the condition is an acute inflammatory condition of the part, goes without saying; yet heat is often, as has been already stated of redness, observed in the hysterical joint, and may be brought about in the same way, *i.e.*, by the application of counter-irritants or apparatus. Here, however, the raised local temperature is not a permanent condition, the joint being hot by day or cold by night, or *vice versa*, while at times comparison with its fellow will show the temperature to be normal or often subnormal. In the more acute diseases of the joints, as well as in the exacerbations of chronic disease, the local temperature shows no such modifications, the rise being a constant one, as is easily ascertained by either the hand or the use of the surface thermometer. It is well to bear in mind that in the more chronic forms of joint-diseases, which are the most often simulated, heat of the part may be altogether absent, and especially is this true of such deep-seated articulations as the hip, shoulder, or the vertebræ. Here we shall have to be guided by the general rather than the local effects of the disease on the temperature. In the real disease there is a marked periodicity in this respect, the rise generally occurring toward evening, and is, as a rule, attended by slight chilliness, perspiration, and flushings. In the mock form this constancy is not observed, any nervous excitement being capable of raising the body heat, with sensations of chilliness and sweats, and at any time. It will, therefore, be seen that careful thermometric observations are necessary to the explanation of the

temperature changes, and their value as estimating the existence of true or false disease of the joints.

It will be observed that the foregoing remarks apply mostly to the symptoms that obtain in the true and false forms of articular disease, rather than to those existing in the simulated troubles of the spine, or to the deformities.

On account of the great frequency with which we are apt to meet the neuromimeses of spinal lesions, inflammatory as in Pott's disease, or deforming as in rotary lateral curvature, we have considered them of such importance as to demand separate attention, and will consider these first, leaving the description of the neuromimeses of special deformities, such as club-foot, for another section. In the spine, as in the diseases of the joints, pain stands foremost as a symptom in both the true and false forms. In the neuromimetic form this is usually complained of at the seat of the supposed disease, and the part, embracing a single or several vertebræ, is unusually sensitive to pressure, the slightest touch at times giving rise to expressions of the greatest agony, which can also be elicited by pressure in the immediate vicinity of the vertebræ supposed to be involved in the diseased process. The pain has all the characteristics of an intense hyperæsthesia of the superficial tissues, and differs in many respects from that found in caries of the bone. It is a well-known fact, usually too little commented on, that in true disease of the vertebræ the pain is reflected to the periphery of the nerves subjected to pressure, and finds its expression anteriorly in the head, chest, belly, and lower extremities, depending on the position of the vertebræ involved in the inflammation. Very rarely is pain complained of at the site of the disease, and when found is not infrequently the result of too much and unnecessary pressure on the part of the surgeon in making his examination, or in consequence of the external application of counter-irritants for the relief of this symptom. As has been seen, this is not the fact in the neuromimetic spine, the pain being distinctly localized in the vertebræ, and very often being such as is commonly found in the so-called "spinal irritation." Here also, as in the false forms of joint-disease, the attention of the patient being withdrawn, the pain temporarily disappears, or it may change its locality from time to time. Where caries of the spine is present, even without the characteristic deformity, its effects on the motion of the diseased area are expressed by a distinct limitation of the normal movements, and attended by a marked reflex spasm of the muscles. On the contrary, in the pseudo-disease, while there may be resistance to motion, it is purely voluntary and easily overcome by persistent, gentle force, while very often, instead of this rigidity, we obtain a decided degree of relaxation in the muscles of the spine. Thus there is very often a complaint of great lassitude, the patient being easily tired and by very trivial causes, and keeping the recumbent posture for long intervals of time. Again, the differences of posture assumed by a patient suffering with Pott's disease and one with a neuromimetic spine are very great.

In the former there is a condition of constant apprehension of pain, expressed by the immobility of the spine which the patient involuntarily accomplishes. The spine is held rigidly, and every movement liable to create distress is carefully executed. No such condition is found in the neuromimetic. While pain is always complained of, the posture is frequently and painlessly changed, and during sleep any position of the spine may be assumed, none of the characteristic osteitic pain or night cry being noticed. Again, in true bony disease, we often have, especially in those cases where the disease is found in the dorsal region, a well-marked paraplegia, which is usually insidious in its onset, and marked by well-known prodromal symptoms.

Paralysis, though by no means an infrequent occurrence in hysterical subjects, and thus liable to happen as a symptom in neuromimesis of the spine, has the following characteristics: It occurs suddenly, without the preliminary symptoms met with in the paraplegia of Pott's disease; the muscles show, except in very old cases, normal reaction to the faradic current; the paralysis is usually confined to a few muscles, or to one extremity, and disappears as suddenly as it occurred, and with these symptoms we have the accompanying ones of the general hysterical state.

The presence or absence of deformity is not always proof of the existence of organic or neuromimetic trouble. In many cases of caries of the spine, especially in the lumbar region, very little or no kyphosis may be present, and in these cases our diagnosis will mainly rest on the muscular expressions accompanying the disease, as manifested by the rigid spine and the psoas contraction. Where deformity exists, however, if the result of an inflammatory lesion, it is a permanent one, and not influenced perceptibly by position. On the contrary, in the neuromimetic spine, while we may have a considerable apparent deformity, it is markedly changed by the altered position in which we may place the patient, usually disappearing entirely in the prone position.

Of all the deformities which are liable to the simulation of real disease, none is so apt to be encountered as that known as lateral curvature of the spine. Being most often first noticed at the age of puberty (although this has not, as has been commonly supposed, an etiological bearing on the production of the deformity), and being also usually attended by a highly emotional condition, it would seem that in these elements might easily be found the causes of its frequent occurrence as a neuromimesis. The most important symptom in cases of true rotary lateral curvature, is the rotation accompanying the lateral deviation of the spine. This is an early symptom, in many cases preceding any noticeable deformity, and only recognized by the altered relations of the scapulæ, one of the shoulders being higher than the other. Another very important symptom at this time is the diminished lateral flexibility of the spine. In the two symptoms just mentioned, namely, rotation and diminished lateral flexibility, we possess the means of diagnosis between the true and neuromimetic lateral curvature. Rotation is never present in the neuromimetic form, and while we may have lateral deviation to a marked extent, this, like the deformity in the false form of caries of the spine, disappears entirely in the prone position, and is never accompanied by the marked loss of lateral flexibility. One of the peculiarities of true rotary lateral curvature is the rarity of pain as a symptom, it seldom occurring until very late in the course of the affection. In the neuromimetic curvature we encounter the same hyperæsthesias as mentioned in the account of joint-diseases and caries of the spine, and having the same characteristics. In this condition, also, the curve is usually a single one, embracing the whole spinal column in its sweep, and, as pointed out by Adams,[12] "so weak and flexible that it will curve in any direction." This is entirely different in character from the true curvature, where it is not possible to change the distorted and rigid spine, and where the deformity is double, a compensatory curve always attending the primary one. With the differences of symptoms already mentioned as distinctive of the true and neuromimetic curvatures, we would add the differences of position as observed in the latter form. Here there is no fixity to the symptoms, as observed in the rotary curvature. The position of the shoulders may change from time to time; the spine may be rigid one day and relaxed the next, and all the symptoms so vary as to leave no doubt as to the existence of the neuromimesis.

It would be impossible in the limits of this article to describe separately all the special deformities which the surgeon is liable to meet, and which can be so closely simulated by the hysterical condition as at times to deceive the most experienced. Neuromimesis of the deformity known as talipes or club-foot, however, occurs comparatively so frequently that some account of it has been deemed necessary. Well-marked instances of hysterical club-foot are reported by Shaw,[13] Sir Charles Bell,[14] Little,[15] Adams,[16] Paget, Brodhurst,[17] Shaffer, Weir Mitchell,[18] and numerous other observers. This deformity, accompanied as it often is by marked hysterical symptoms, partakes of the nature of those cases

which Charcot [12] has described as "permanent contracture," and with it are frequently associated similar contractures at the knee and hip. These contractures very closely simulate those produced by an organic lesion of the cord or brain, being unaffected by the withdrawal of volition, as in sleep, and only disappearing under complete anæsthesia. An important distinction, however, is found in the different condition of the muscles involved, under the stimulus of the electric current. In the organic contractures these are markedly affected, and we always find diminished faradic contractility. The muscles of the hysterical contracture, on the contrary, give a normal faradic reaction, and with this we find the simple atrophy of disuse. Although all forms of talipes may be simulated by the hysterical condition, the one usually assumed in the neuromimetic variety is that of a varus or inversion of the foot, and Dr. Little has described this position as follows: "Its outer margin alone touching the ground, the sole presenting vertically backward, the tibialis anticus, tibialis posticus, and gastrocnemii tendons being tense from contraction of their respective muscles, and toes firmly incurvated." With this position of the foot Shaffer has found as being present, in every case of hysterical club-foot seen by him, "a peculiar and extreme flexion of the toes," and states that "in true talipes this condition does not often exist, and its presence may be looked upon as an indication of the hysterical state." In estimating the value of the symptoms, when the question arises as to the existence of this neuromimesis, much care must be taken in the consideration of all the facts entering into the problem. Foremost among these are the age, the previous condition and surroundings, and the general health of the patient, and here again the conditions as stated in the remarks on etiology, will be of great service in the diagnosis of the malady. In this as well as in other deformities depending for their production on the hysterical state, the symptoms begin abruptly. After the occurrence of the more common hysterical manifestations, it is noticed that the patient walks peculiarly, and an examination reveals the presence of an inversion of the foot. With this, pain of a severe kind is complained of, and the patients are disinclined to move about on this account. The walk is stiff and awkward, the limp exaggerated, and with this there is a feeling of weakness in the limb. Often on manipulation of the foot it is found so rigid as to give the impression that anchylosis exists, and this rigidity persists even in sleep. After the deformity has persisted for a long time atrophy will be found. It will be seen by this description that many of the symptoms entering into the clinical picture of true club-foot are present, and, without the history of hysteria, or where this condition, as it often does, assumes a latent form, or is masked or overshadowed by the prominent symptoms present, would give rise to the greatest trouble in diagnosis. Each case, then, will demand careful study, and it is only by the especial consideration of the previous history, the differences existing in the electrical reactions, the effects of anæsthesia on the contractures, and by such other means as we have briefly endeavored to describe in the previous lines, that we can best arrive at conclusions concerning the presence of the neuromimetic form of club-foot.

Diagnosis.—The description of this class of cases is necessarily of such a clinical nature that many of the remarks properly belonging to this section have already been enumerated in writing of the symptoms. Still there are some salient points that will briefly demand our attention. Of the greatest importance in the diagnosis of neuromimesis is the disproportion between the long continuance of the malady, and the slight amount of local changes as a result thereof. Thus, in the cases of joint-disease, the patient may have been a sufferer for months with all the symptoms of an aggravated nature, intense pain, deformity, apparent shortening or lengthening, and diminished mobility of the articulation, without the distinctive atrophy showing itself in the manner so characteristic of true articular disease. Again, the evanescence or constant changing in the nature of the symptoms, both as pertaining to the seat of complaint and to the functions of the part, are typical of the neuromimesis. [illegible] inconsistencies, then, in the various symptoms are [illegible] important in the differentiation of the true from the false cases of disease or deformity, and thus where, with intense pain and immobility, the temperature of the part remains normal, there exist none of the local [illegible] of inflammation or of evidence of degenerative change, and the tissues give the peculiar white and natural appearance of health, we can almost always predicate the presence of actual organic disease, and safely diagnosticate the neuromimetic trouble. Diagnosis is not difficult in those cases where hysterical or other nervous symptoms have been present and disappear with the occurrence of the local manifestation of the general condition, as either a joint-disease or deformity, or where the *tout ensemble* of the patient makes it plain that we are dealing with a disease of the nervous system. Very difficult, on the other hand, is it when the given cause is a traumatic one, such as we find in real cases resulting in inflammatory changes in the joint. It must not be forgotten that the two conditions may exist at the same time, as in a case related by Esmarch, where, with marked hysterical symptoms, there existed a state of the ankle-joint which he was for a long time inclined to explain on the ground of a neuromimesis, but which ultimately an amputation showed to be in a condition of "caries sicca." Hueter also mentions a similar case, where the symptoms pertaining to the hip-joint were supposed to be hysterical in their nature, but where, after the lapse of several years, examination revealed anchylosis of the articulation. It is evident, then, that no class of cases will call for greater care in properly testing the value of each symptom, and weighing scrupulously all the facts entering into the case, than those we are considering; for while these pseudo-diseases are of no importance as relating to the life of the patient or to the ultimate function of the part involved, the opposite mistake of treating a true disease as a false one has led to the most disastrous results.

Treatment.—Being satisfied that the disease or deformity dealt with is the result of a general disturbance of the nervous system, it is evident that the treatment of all forms of neuromimesis, be they of the joints, spine, or a deformity, should primarily be addressed to the "morale" of the patient. This should be an axiom in dealing with these cases, although in the application of it we shall often have to resort to means whereby the subjective symptoms can be controlled, and the discomfort of the patient lessened. In all these cases the use of the term "hysteria" should be used with the greatest caution, for with the amount of actual suffering which these patients endure, often more than if there was a real pathological condition present, the explanation of it as being all due to hysteria will be badly received, and in the majority of cases the confidence of the patient, so necessary to the successful treatment of the case, will thus be lost. In all these cases the treatment should be addressed more to the mental than to the physical condition, and this will depend largely on the amount of control which can be exercised over the patient. Once the diagnosis is verified and the confidence of the patient obtained, any order given should be carried out with the greatest firmness. In this it is not necessary to use any but the most gentle means, but there must be no wavering, no concession, for if the control of the patient be once lost it cannot be regained. Many of the patients keep to their beds, strenuously declaring their inability to walk, and here it is often possible, with the exercise of some tact, to make them get up and walk about on the first visit. Where it is possible it is always of great value to obtain the co-operation of the patients, by making them use their will-power in the performance of certain motions, and also in overcoming the sense of pain. This will be found difficult, however, unless the patient be very intelligent and possessed of a real desire to recover. Another very important measure is the withdrawal of the patient's attention from the diseased spot, and this can be done in several ways. Barwell mentions an expedient he found

useful, and which consisted of the passing of a seton through a small fold of skin, at some considerable distance from the seat of pain, the success of the plan depending on the belief that when the silk comes away the pain will leave. Another method is the performance of some slight operation, the purpose of which has been explained at length to the patient. Such practices are, however, very risky, inasmuch as these results do not always follow as we would wish them to, and notwithstanding the fact that cures of neuromimesis have been brought about in this way, we agree entirely with Tuke[20] when he says: "In regard to misleading patients generally, even *casui secundo*, one of the practical difficulties the investigation presents is certainly the unseemliness of making experiments of this nature, and the danger of sullying that strict honor which by no profession is more prized or maintained than by the professors of the medical art."

In the treatment of these local effects of some disturbance of the nervous system, it is of the utmost importance to investigate all those organs, whether it be the uterus, the digestive system, stomach, liver, spleen, or intestinal tract, in search of some perverted condition which may reflexly be the cause, or assist in the maintenance, of the trouble; and should any such condition be found, its removal, if possible, will be the first object to be accomplished. Thus the adoption of hygienic measures which best serve to improve the health and increase the strength, such as proper food, sleep, rest, and warmth, with regular exercises followed by rest, will be markedly beneficial. For in the great majority of these cases the hysterical condition will be found engrafted on some form of debility the result of the habits and mode of life of the patients, and which are perpetuated by the injurious influences surrounding them, their whole existence being an emotional one—all of the functions, whether of mind or body, being unexercised and continually subject to unwholesome excitement. Thus again, the misdirected but well-meant sympathy of relatives and friends is an element with which much trouble is experienced in treatment, and it is often necessary to remove the patient from home before benefit is received. The general indications having been observed, it will be found necessary to use such local measures as give either strength or comfort to the part involved. Thus all those agents which are beneficial in relieving local pain may be called for, being employed either in the form of lotions, ointments, or plasters, the substances used, some form of opium, belladonna, aconite, or the like, being indicated by the nature of the pain or the idiosyncrasies of the patient. Again, the use of frictions, either in the form of systematic "massage" or movements, following the use of the hot or cold douche, have been followed by benefit. Galvanism to the affected part, in those cases where there occurs either weakness or contracture is also indicated. The great objection to the use of all local measures is, that even with the relief of pain they become the means of continually directing the attention of the patient to the part, and thus the importance of the symptoms is constantly magnified by the imagination.

The use of apparatus in the treatment of these hysterical conditions is very rarely indicated, for the same reasons urged against the employment of local remedies; an exception, however, may be made in the case of long-continued contraction from muscular rigidity, where, after restoration to the normal position, the limb is retained by means of a splint. Despite this artificial restraint, the part subjected to it often relapses to its deformed posture after removal of the retention apparatus, and in certain cases, even after all symptoms of the general hysterical condition have been removed by appropriate treatment, the deformity still remains and, at times, even necessitates the performance of tenotomy, as in a case of hysterical club-foot reported by Weir Mitchell. Many of these cases terminate as suddenly as they appeared, without any cause for the disappearance of the symptoms; some cases have been known to recover suddenly after some forcible impression on the nervous system by a blow, or fall, or nervous excitement. Skey mentions the case of a young lady, who for eight months had been treated for an hysterical inversion of the foot, "so twisted as to bring the point of the foot to the opposite ankle." Recognizing the nature of the deformity, Skey removed the apparatus with which she came to him. At the end of six weeks, during which little progress had been made in the treatment, she received an invitation to a ball. She entered the ball room with the foot still in its abnormal position, but upon being invited to dance, and under the novel excitement, she stood up and danced the whole evening, having suddenly recovered the healthy muscular actions of the limb. When seen two days afterward, all traces of the previous malady had disappeared. It is in this form of disease or deformity that so much success is attained in treatment by the "faith cure" and other forms of charlatanism, cases frequently recovering simply by the influence of belief in certain things after having for years been treated in various ways; the cure in these instances being simply an inversion of the emotions bringing about the diseased condition, and influenced through them; as it is well known that they are just as efficient in relieving abnormal conditions as in the production of them. Finally, the danger of relapse in these cases must not be forgotten; patients frequently returning after long intervals either with the same disease, although with other symptoms, or with an entirely new manifestation of hysteria in the form of articular disease or deformity.

In the preparation of this article the following works have been consulted:

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[5] Bauer: Lectures on Orthopædic Surgery. New York, 1868.
[6] Barwell: Treatise on Diseases of Joints. London, 1881.
[7] Skey: Lectures on Hysteria. New York, 1867.
[8] Shaffer: The Hysterical Element in Orthopædic Surgery. New York, 1880.
[9] Esmarch: Ueber Gelenkneurosen. Kiel, 1872.
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[11] Valtat: De l'Atrophie musculaire consecutive aux Maladies des Articulations. Paris, 1877.
[12] Adams: Lectures on Curvature of the Spine. London, 1882; second edition.
[13] Shaw: Further Observations on Distortion of the Spine. London, 1825.
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[15] Little: Club-foot and Analogous Distortions. London, 1839.
[16] Adams: Club foot: Its Causes, Pathology, and Treatment. London, 1873; second edition.
[17] Brodhurst: Club-foot. London, 1856.
[18] Weir Mitchell: Lectures on Diseases of the Nervous System. Philadelphia, 1885.
[19] Charcot: On Diseases of the Nervous System, New Syd. Ed., 1877.
[20] Tuke: Influence of the Mind upon the Body. London, 1872.

Samuel Ketch.

NEWBURY SPRINGS. *Location and Post-office*, Newbury, Orange County, Vt.

Access.—By the Passumpsic Railroad, extending from White River Junction, Vermont, to Quebec, Canada.

Analysis (Professor Hall).—One pint contains:

Sulphur Springs.

	Grains.
Carbonate of soda	0.50
Carbonate of lime	2.20
Carbonate of magnesia	0.30
Chloride of sodium	0.04
Sulphate of soda	0.30
Sulphate of magnesia	0.05
Protoxide of iron	trace
Phosphate of iron	0.05
Nitrate of potassa	0.05
Hydrosulphate of soda	0.04
Silica and suspended clay	1.10
Organic matter and ammonia	0.03
Total	4.66

Sulphuretted hydrogen gas, undetermined.

The iron springs have not yet been analyzed. These springs, also known as the Montebello Iron and Sulphur Springs, are situated on the eastern border of Vermont, in the Connecticut River Valley. The scenery is most picturesque. There are beautiful river and valley views, and from Mounts Pulaski and Montebello the views of the White Mountain range are most sublime. Excursions to the summit of the White Mountains and return

can be made in a day. Newbury has a population of about one thousand, and contains churches and schools. The hotel at the Springs is a two-story building, with a wing fitted up with bath-rooms. *G. B. F.*

NEW MEXICO. The Territory of New Mexico lies immediately to the east of Arizona Territory, between the same parallels of latitude (31° 22′ 30″ N. and 37° N.), and having a width from east to west which is very nearly the same as that of Arizona: the total area of the territory, 122,460 square miles,* is about seven per cent. greater than that of its sister territory. In climate both territories are very much alike, the chief difference between them depending upon the fact that [illegible] tion of Arizona lies at a very moderate [illegible] sea-level, in New Mexico the elevation [illegible] greater, never falling below 3,700 feet, even in the valley of the Rio Grande, near the southern border, the [illegible] lying portion of the territory, while toward the northern limit it rises to 6,000 or 8,000 feet. The hypsometric map of the United States, published in the Tenth Census, shows an elevation of from 6,000 to 10,000 feet for about a quarter of the territory, and an elevation of from 4,000 to 6,000 for all the rest of its area. To illustrate the peculiarities of the New Mexico climate in respect to temperature and rain-fall, the following tables, A, B, and C,

TABLE A.

Name of Station.	Latitude.	Longitude.	Height above sea-level.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.	Series. Begins.	Series. Ends.
	° ′	° ′	Feet.																			
Fort Union	35.54	104.57	6,670	32.03	35.43	40.82	49.08	58.83	66.49	69.87	67.46	61.55	51.35	41.56	33.03	49.58	67.94	51.49	33.50	50.63	Aug. 1851	Dec. 1870
Santa Fé	35.41	106.02	6,846	28.38	33.21	40.73	50.27	59.17	69.36	72.13	70.01	63.79	51.79	38.44	29.25	50.06	70.50	51.34	30.28	50.54	Jan. 1849	Dec. 1870
Las Vegas	35.35	105.16	6,418	33.36	31.20	37.23	47.07	56.41	67.82	71.41	73.01	66.47	48.88	32.98	21.73	46.90	70.75	49.44	28.76	48.96	Jan. 1850	July, 1851
Socorro	34.05	106.50	4,560	37.60	38.05	48.74	57.31	65.69	76.46	79.60	80.48	73.61	60.38	42.60	33.30	57.25	78.85	58.86	36.32	57.82	Nov. 1849	Aug. 1851
Albuquerque	35.06	106.38	5,032	32.77	38.19	47.09	56.07	65.92	74.24	78.36	76.22	68.80	56.88	43.29	33.39	56.36	76.27	56.32	34.78	55.93	Sept. 1849	July, 1867
Fort Bayard	32.46	108.30	4,450	36.38	39.56	43.97	51.67	58.49	69.25	71.13	69.91	66.61	57.87	45.86	38.68	51.38	70.10	56.78	38.21	54.12	Mar. 1867	Dec. 1870
Fort Selden	32.23	106.55	4,250*	44.12	48.06	55.46	63.55	72.89	81.53	82.57	80.27	74.77	63.54	51.89	43.10	63.96	81.46	63.40	45.09	63.48	Nov. 1865	Dec. 1870
El Paso, Tex	31.44	106.32	3,830	45.75	49.25	60.36	74.31	77.92	87.36	88.53	87.06	85.22	70.00	....	38.37	70.86	87.65	....	44.46	....	Aug. 1850	Aug. 1851
Fort Bliss, Tex	31.47	106.30	3,830	44.22	49.52	57.64	64.75	74 48	81.46	83.03	80.49	74.93	65.09	54.55	52.10	65.62	81.66	64.86	48.61	65.19	July, 1854	Dec. 1870

* Elevation of Fort Selden taken from Report of Dr. Jessup, U. S. Army, quoted in Dr. W. Thornton Parker's pamphlet, Concerning the Climate of New Mexico.

are introduced. The data in these three tables, as in the case of three similar ones published under the title Arizona, in vol. i., are copied from larger tables contained in the "Smithsonian Contributions to Knowledge," Nos. 277 and 222.

The figures of Table A show the mean temperature of each month and season, and of the year, at the selected stations. In each instance the latitude of the station appears to have less weight in determining its temperature than has the factor of elevation above sea-level. The stations are mentioned in the order of their latitude (which also in this instance happens to coincide pretty closely with the order of their respective elevations); one exception to this rule being made, however, in the case of the station Socorro, which I place next to Las Vegas on account of the shortness and close coincidence of the periods of observations at these two stations. The data for Fort Bliss and El Paso do not, strictly speaking, belong in a chart representing the climate of New Mexico; nevertheless I include them, because, while El Paso lies across the Texan boundary line, it is but a few miles beyond that line, and, climatologically considered, belongs quite as much to New Mexico as does Fort Selden; these two places standing but fifty-five miles apart, and, with Albuquerque and Socorro, constituting a series or chain of places, all of them lying in the Rio Grande Valley, but each differing from the others in respect to latitude and elevation. The El Paso data are taken from the New Mexico list in No. 277 of the "Smithsonian Contributions"; the Fort Bliss data are from the Texas list in the same publication. The "El Paso" period of observations is very short, yet its data are very properly comparable with those from Las Vegas, and with those from Socorro. In making this comparison, the respective values of latitude and of elevation in modifying temperature will be appreciated. The reader's attention is called to the *relatively* small annual variation in temperature at Fort Bayard, where the difference between the mean temperatures of winter and summer is less than at any other station given in Table A, and where we find a mean summer temperature which is a trifle cooler than that of New York City, and a mean winter temperature which is only three degrees lower than that of Norfolk, Va. The El Paso climate, as indicated by the data from the military post of Fort Bliss, and from El Paso itself, is exceedingly warm in summer: in winter the mean tempera-

TABLE B.

Name of Station.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Series. Begins.	Series. Ends.
Fort Union	74	70	79	85	94	100	101	96	90	89	87	72	Aug. 1851	June, 1874
	−13	−7	−4	15	20	25	40	32	28	9	5	−28		
Santa Fé	65	66	77	91	92	98	99	100	91	82	78	68	June, 1849	July, 1873
	−9	−2	8	19	28	39	50	49	34	3	3	−11		
Albuquerque	66	78	83	98	100	114	110	105	98	96	86	66	Sept. 1849	July, 1867
	−4	0	12	22	28	38	50	44	40	20	8	−5		
Fort Bayard	64	70	76	86	92	100	96	97	89	85	71	68	Mar. 1867	June, 1874
	−8	−1	12	9	29	35	50	50	40	12	3	8		
Fort Selden	72	80	86	98	106	105	104	105	99	94	79	74	Nov. 1865	June, 1874
	−12	11	15	27	33	52	49	52	39	18	4	9		
Fort Bliss	78	86	89	98	107	112	109	107	103	99	85	78	July, 1854	June, 1871
	11	12	18	28	41	54	58	56	51	25	11	11		

ture of this place is but two and one-half degrees lower than that of Charleston, S. C.

The data of Table B show the absolute maximum and the absolute minimum temperatures observed at each station during the period of observations stated in the right-hand column. They are not based upon observations made with maximum and minimum thermometers, but present only the extremes recorded at the regular hours of observation. Again in this table we have an opportunity of estimating the *relative* equability of the climate of Fort Bayard. The latitude and the elevation of Fort Bayard are very nearly the same as those of Fort Selden; yet the former station is subject to less extremes of heat in summer than is the latter, and in winter the minima at Fort Bayard are about the same as at Fort Selden. That even Fort Bayard is far from

worthy of classification among places possessing a truly equable climate is shown most clearly by the extreme possible range which is indicated by the figures of the table. El Paso is subject to less extreme depressions of temperature than are Fort Bayard and Fort Selden; but, as we see distinctly from the figures in Table B (Fort Bliss), equability can by no means be claimed even for this station. In *mean* winter temperature El Paso closely resembles Charleston, S. C.; in *extreme* winter temperature there is little or no likeness between the two places.

TABLE C.

Name of Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.	Series. Begins.	Series. Ends.
Fort Union	0.58	0.35	0.55	0.49	0.75	2.83	5.97	5.16	2.56	1.03	1.14	0.45	1.79	13.96	4.73	1.49	21.88	Sept. 1851	Mar. 1863
Fort Marcy*	0.47	1.84	0.74	0.84	0.72	1.55	2.75	3.28	1.95	1.15	0.98	0.85	2.25	7.09	4.12	2.66	16.05	Feb. 1850	Dec. 1865
Las Vegas	...	1.23	0.61	1.06	2.82	0.09	5.10	...	0.00	0.00	0.12	0.13	3.89	...	0.12	...	...	Apr. 1850	July. 1851
Socorro	0.01	0.18	0.09	0.15	0.05	0.09	0.84	1.30	0.24	1.81	1.31	0.62	1.10	2.23	3.39	1.14	7.86	Nov. 1849	Aug. 1851
Albuquerque	0.31	0.25	0.28	0.32	0.23	1.57	1.05	1.93	0.83	0.81	0.40	0.36	0.85	4.35	2.04	0.90	8.12	Feb. 1850	July. 1897
Fort Bayard	...	...	0.65	0.29	...	0.00	4.45	2.19	1.60	0.75	0.55	1.50	...	6.64	3.99	...	...	1897	1897
Fort Selden	0.10	0.60	0.60	0.00	0.01	...	4.31	0.80	1.81	0.26	0.43	0.20	0.61	...	2.50	0.90	...	Jan. 1896	Dec. 1897
Fort Bliss, and El Paso	0.10	0.95	0.53	0.50	0.13	0.25	1.02	2.00	2.79	0.88	0.87	0.26	0.46	3.25	4.54	1.31	9.56	Aug. 1850	Dec. 1867

* Lat. 35° 41′ N.; Long. 106° 02′ W. Elevation, 6,846 feet. Near Santa Fe.

The data in Table C are those of average rain-fall. The figures for Santa Fé (Fort Marcy), for Albuquerque, and for El Paso are of decided value as an indication of the climate of these places in respect to rain-fall. In the cases of Fort Bayard, Fort Selden, Las Vegas, and Socorro, the observations are not sufficiently extended to be of great value in point of accuracy. A consideration of all data presented in the table shows the small amount of the annual rain-fall throughout the whole region, and the division of the year into a so-called "rainy" and a dry season, the latter occurring in winter and spring, the former in summer and autumn.

In Table D, I present data of the mean temperature, mean rain-fall, and average number of clear, fair, and cloudy days, and of days on which rain fell, at El Paso, Tex. The figures of this table I have calculated from a table published by Dr. E. W. Schauffler, of Kansas City,[1] which comprises the period between July 1, 1881, and July 1, 1883, and from a table contained in the "Report of the United States Chief Signal Officer for 1881," which covers the twelve months immediately preceding, viz., from July 1, 1880, to July 1, 1881. Dr. Schauffler's table was taken from similar reports for later years, which I have not in my possession. The reader's attention is called to the extraordinary cloudlessness of the sky at El Paso; to the small rain-fall shown in this, as in the preceding, table (Table C); and to the very small number of days upon which a fall of snow occurred (see note under December in column of days of rain). The figures for mean temperature will be seen to correspond pretty closely to those given for Fort Bliss in Table A. The latter were derived from observations made at 7 A.M., 2 P.M., and 9 P.M., the 9 P.M. observation being added twice and the sum divided by four to obtain the daily mean, in accordance with the formula,

$$\frac{7\text{ A.M.} + 2\text{ P.M.} + 9\text{ P.M.} + 9\text{ P.M.}}{4}$$

In Table D, the mean is calculated by the formula,

$$\frac{7\text{ A.M.} + 3\text{ P.M.} + 11\text{ P.M.}}{3}$$

With regard to the state of the sky and the frequency of rain, we learn from Table D that at El Paso in the course of a year there are, on the average, no less than 228.5 clear days, 105.5 fair days, and but 31 cloudy days; and that rain falls upon only 82 days. During the four months December to March the average total number of days on which rain falls is but 19, while the average number of clear, fair, and cloudy days is as follows: clear, 72; fair, 35.5; cloudy, 13.5. These averages are derived from only two years of observation. When corrected by the figures for the year 1884, which are quoted by Dr. Schauffler on the authority of the El Paso Bureau of Information, they would stand as follows: For the year: clear, 210; fair, 117; cloudy, 37. For the four months December to March: clear, 67; fair, 39; cloudy, 14. The reader may, perhaps, observe that I speak of "days on which rain falls," and not of "days of rain," or "rainy days;" and a comparison of the four "Days" columns of Table D will show him why I have done so. The fallacy of the conception as to what constitutes a "rainy season," which is so commonly held in places where no such season exists, is demonstrated in a striking manner by the "fair," "cloudy," and "rain" columns of July and August in the table.

Although no data of average daily maximum and minimum temperatures are presented in Table D, a comparison of the 7 A.M. and 3 P.M temperatures nevertheless suffices to indicate the existence of a very considerable nycthemeral range of temperature at El Paso, although it by no means measures such range, and does not demonstrate its full magnitude. On page 238 of vol. ii. of this HANDBOOK the reader will find a table wherein are given figures showing the mean daily, or nycthemeral, range of temperature at Santa Fé, a station lying some two hundred and seventy-five miles north of El Paso, and at a much greater elevation above sea-level. It will be remembered that even at El Paso the elevation above sea-level is very considerable (see Table A), and that, as already stated, such considerable elevation characterizes all portions of the territory of New Mexico.

TABLE D.

(*El Paso, Tex., July, 1880, to July, 1883.*)

Month.	Temperature. 7 A.M.	3 P.M.	11 P.M.	Mean.	Rain fall and melted snow in inches.	Days. Clear.	Fair.	Cloudy.	Rain.
January	32.5	52.2	42.1	42.26	0.363	17.5*	11.0*	2.5*	3.0
February	39.3	58.8	49.2	49.10	0.473	13.0*	9.5*	5.5*	7.5
March	44.5	66.1	55.1	55.23	0.826	18.5*	7.5*	5.0*	4.0
April	50.2	75.5	62.3	62.66	0.160*	24.5*	4.0*	2.5*	1.5
May	58.5	83.6	71.0	71.03	0.650	26.5*	2.5*	2.0*	5.0
June	68.1	94.8	80.1	81.00	0.156	20.0*	9.5*	0.5*	5.5
July	70.8	93.3	79.5	81.20	5.326	10.5*	18.0*	2.5*	14.5
August	67.9	88.1	75.1	77.03	3.090	17.0*	10.5*	3.5*	17.5
September	60.2	83.5	68.8	70.83	0.880	21.5*	5.2*	3.0*	8.0
October	49.5	76.4	60.5	62.16	0.960*	20.5*	10.5*	0.0*	6.0
November	37.1	59.4	46.7	47.83	0.660	17.0*	9.5*	3.5*	5.0
December	34.5	55.5	42.7	44.16	1.155*	23.0*	7.5*	0.5*	4.5†

* Average derived from two years' observations only.
† In December, 1880, there were two days on which snow fell. No other fall of snow recorded from July, 1880, to July, 1883.

Moreover, as will appear from data about to be quoted, the dryness of the atmosphere throughout the whole of this region is extreme. Consequently, we should naturally expect a great nycthemeral range of temperature at all points included within the limits of the region. From U. S. Signal Service data in my possession I am able to quote the following figures, giving the mean relative humidity for the year and for the winter at four stations, viz.: At Santa Fé (period of observations, December, 1871, to June 15, 1883), at La Mesilla, in the Rio Grande valley, some thirty-five miles north of El Paso (observations, July, 1880, to July, 1881); at Silver City, near Fort Bay-

ard (July, 1880, to July, 1881); and at El Paso (July, 1880, to 1881).

TABLE E.

Mean Relative Humidity.

	Winter.	Year.
	Per cent.	Per cent.
Santa Fé	52.1	43 9
La Mesilla	43 8	41 6
Silver City	49 6	50.9
El Paso	38 4	45.7

Dr. J. Hilgard Tyndale[5] presents similar data for La Mesilla and Silver City, derived from several years of observation (U. S. Signal Service) at each station. At La Mesilla these observations extended from September, 1877, to August, 1882. The absolute maximum of relative humidity observed during that period was only 64.5 per cent.; the absolute minimum was 22.5 per cent. The mean for the six months November to April was 51.6 per cent.; that for the entire year was 43 per cent. At Silver City (observations, May, 1878, to December, 1882) the annual mean was precisely the same; the mean from November to April was 58 per cent.; the absolute maximum was only 67.8 per cent.; the absolute minimum was 18.8 per cent. In the following table (Table G) I present Dr. Tyndale's figures, giving the range of temperature *on the first day of each month*, from July, 1879, to July, 1880, at La Mesilla, Socorro, and Santa Fé.

These figures would not be a safe guide to the estimation of *average* nycthemeral range, but they indicate the variability of the New Mexico climate even more *vividly* than do such figures for *average* daily variation.

TABLE F.

Actual Range of Temperature Observed on the First Day of each Month, July, 1879, to July, 1880. (Dr. J. H. Tyndale.[5])

Date.	Santa Fé.	Socorro.	La Mesilla.
July 1, 1879	40	28	49
August 1, 1879	32	18	35
September 1, 1879	32	32	46
October 1, 1879	22	24	36
November 1, 1879	23	18	39
December 1, "	34	33	44
January 1, 1880	28	13	21
February 1, "	14	16	21
March 1, "	41	34	43
April 1, "	34	30	35
May 1, "	25	28	32
June 1, "	40	34	33

These figures are derived from observations made with maximum and minimum thermometers, and the data from which they are derived are published in the "Report of the Chief Signal Officer, U.S.A.," for 1880. In this report the maximum and minimum temperature of each day of the whole year are given, and, taking a single month (July, 1879), as an example, I find by calculation that the average daily range at Santa Fé was 31.71° F., or about 5° F. higher than the normal daily variation for that month at that place (see vol. ii. of Handbook, page 268, Table F), while the least daily variation occurring throughout the month was 22° F.

Before proceeding to a general descriptive discussion of the climate, scenery, soil, etc., of New Mexico, and to a special, though brief, consideration of El Paso and of a few other points lying within this region, I give one more table (Table G) setting forth the mean monthly temperatures at Fort Union, and giving the mean of the absolute monthly maximum and minimum temperatures at that place during a period of four years and two months. The data of this table are calculated from figures entered in the Post Hospital records, and quoted by Dr. W. Thornton Parker in his pamphlet "Concerning the Climate of New Mexico" (reprinted from the *Archives of Medicine*, vol. xii., No. 2, October, 1884). The observations upon which the table is based extended from March 1, 1880, to May 1, 1884.

TABLE G.

Temperature at Fort Union, Elevation, 6,835 feet. (*March, 1880, to May, 1884.*) (Dr. Parker.[2])

	Monthly mean.	Mean of absolute maxima for month (July 1880 to May 1884).	Mean of absolute minima for month (July 1880 to May 1884).
January	29 16	63 50	19 75
February	34 46	64 50	12 50
March	40 32	69 00	8 00
April	48.58	75 20	9.60
May	57 88	81 00	35 25
June	69 28	92 75	44 75
July	69 14	92 50	44 25
August	65 90	85 50	39 75
September	60 11	84 25	24.25
October	49 42	77.00	15 00
November	35 54	68 25	7 25
December	34 41	68 25	5 75

The absolute maximum during the entire period was 96° F.; the absolute minimum was 0° F. Temperatures of 10° F. or less are recorded as having occurred in February, March, and April. In January, 1880, which is not included in the period from which data are calculated, a temperature of 5° F. occurred.

Dr. Parker tells us[2] that the total fall of rain and melted snow at Fort Union, for the years 1880–83, was as follows: 1880, 19 inches; 1881, 22 inches;* 1882, 9.41 inches; 1883, 14.50 inches.

There are six points, concerning each of which brief remarks shall be made in this article, viz., Fort Union and Las Vegas Hot Springs, in the northern or most elevated portion of the Territory; Silver City, in the southwestern part (a region of medium elevation, *as elevations go in New Mexico*); and Fort Selden, La Mesilla, and El Paso, in the "Mesilla Valley" (the most southerly and lowest-lying district in the Territory). Santa Fé will be described elsewhere in a separate article.

Fort Union.—Of Fort Union we are told by Dr. Parker,[2] who quotes from Dr. W. H. Gardner, U. S. A., that it "is situated in a narrow valley on the eastern slope of the Rocky Mountains, and is about 6,835 feet above the level of the sea;" that "the diurnal variation in temperature is very great, the thermometer frequently showing at 6 A.M. but 60°, and at 2 P.M. 97°;" and that, "even in midsummer nights, one or more blankets are always comfortable to sleep under." Also that, "wind from some quarter is almost constant, and the soil being light and sandy, is blown about in clouds of blinding, suffocating dust, that irritates the air-passages, and is the prevalent cause of catarrhs, pharyngitis, and bronchitis." Dr. Gardner believes the climate of Fort Union to be unfavorable for any kind of lung disease; he also describes in interesting detail his own sufferings, shortly after arriving at the post, from various symptoms affecting the respiratory, circulatory, and nervous systems; symptoms which were due, in his belief, to the diminished atmospheric pressure at a point so far elevated above sea-level. Dr. Parker testifies to the fact that the experience of Dr. Gardner in this respect was not unique. In his own case, and in that of two other persons similarly affected, Dr. Gardner found these distressing symptoms relieved after a change in diet, consisting in diminution of the amount of nitrogenous food, and in a freer use of laxative vegetables and fruit. In the case of an

* The rainfall in 1881 seems to have corresponded closely to the average as stated in Table C. The mean temperatures of Table G correspond pretty nearly to those given in Table A. When, however, we come to consider the maximum and minimum temperatures given in the tables published by Dr. Parker (the averages of which are calculated and set down in the second and third columns of Table G), we are struck by a lack of correspondence between these data and those of Table B. This seeming inconsistency may perhaps be explained as follows: In the first place, the absolute maxima and minima of Table B are derived from a far longer series of observations than are the absolute maxima and minima in the separate annual tables quoted by Dr. Parker. In the second place, we know from Smithsonian Contribution No. 277, page 54, note) that, prior to 1854, the observations at Fort Union were made at sunrise, 9 A.M., 3 P.M., and 9 P.M., instead of at 7 A.M., 2 P.M., and 9 P.M., we are also told (op. cit., p. 262) that maximum and minimum figures, such as are quoted in Table B, were derived from the regular daily observations, and not from the use of self-registering maximum and minimum thermometers: hence we see that it is quite possible that the absolute lowest minima in Table B may have been observed at sunrise, and that the absolute highest maxima may have been observed at 3 P.M.

invalid affected with a disease which would be liable to embarrass the heart's action even at a moderate elevation above sea-level, the simple remedy which Dr. Gardner believes to have proved efficacious in the removal of such very serious symptoms as he describes could hardly be relied upon as all-sufficient. (See cautionary remark under section on Chronic Bronchitis, etc., in article Health Resorts, vol. iii. of HANDBOOK, page 533.) The water-supply at Fort Union appears to be inferior in respect to quality; for Dr. Parker, speaking apparently of that post,[2] and commenting upon its variable summer climate, tells us that "these sudden changes, together with the action of the water, excite a loose condition of the bowels;" and that "diarrhœa, and even dysentery, are of frequent occurrence." Other effects of the climate he alludes to as follows: "The high altitude affects most people very unpleasantly, at least for a time, and many suffer until they leave the country. 'Nervousness,' neuralgias, and all heart troubles seem to increase. . . . Weariness, languor, confusion of ideas, inability for exertion or study, depression of spirits, almost to despair, are common ailments due to this climate and elevation. Fast walking and running are out of the question, and troops are not allowed to be drilled in the 'double quick.' Loss of appetite, indigestion, dyspepsia, and biliousness, show that the intestinal tract is affected by the change. Colds, catarrh, etc., are very prevalent; and pneumonia is rapidly and generally fatal." Finally, he states that at Fort Union itself there are no accommodations whatever for invalids, although at Watrouse, a town eight miles south of the military post, "very simple accommodations" could be had for summer residents. "It could not be recommended at all in winter."

LAS VEGAS HOT SPRINGS.—This point is mentioned by Dr. Parker[2] as being "probably the pleasantest spot in the whole Territory, and the healthiest, unless we except Santa Fé." Both he and Dr. Tyndale allude to Las Vegas Springs as one of the places in New Mexico which are best sheltered from the winds. "The Springs are set in the midst of the foothills so cosily, that violent winds and dust-storms lose most, if not all, their tormenting power."[2] In respect to this matter of shelter from winds, Dr. Tyndale is careful to distinguish between Las Vegas Springs and the *town* of Las Vegas, from which they are distant some seven miles. The elevation of the Springs above sea-level is 6,700 feet; very nearly the same as that of Fort Union and of Santa Fé. As a mineral spring resort the Las Vergas Hot Springs will be found described elsewhere (vol. iv., page 450). The data for mean temperature and mean rainfall in Tables A and C are evidently from the town of Las Vegas, not from the Springs. How far the sheltered situation of the Hot Springs, and the presence there of the heated springs themselves, may tend to modify the climate, I do not know. As a purely climatic resort, Las Vegas Hot Springs may be a good place for the invalid during the summer months, provided its great elevation above sea-level be no contra-indication. As a winter resort it is probably not to be recommended. Full and trustworthy meteorological data may show to the contrary, but such data are not in my possession. Clinical experience would, of course, be the best guide in this question, but on this point, also, I am not in a position to speak, lacking the proper data.

SILVER CITY.—Silver City lies near Fort Bayard, about sixty miles west of the Rio Grande Valley. This is one of the points in New Mexico mentioned by Dr. Tyndale[5] as enjoying the exceptional advantage of shelter from wind. A glance at a good map of the Territory (see, for example, the map in vol. xvii. of the "Encyclopædia Britannica") will show why this is so. The reader's attention is also called to the large number of "calm" observations recorded between November 1, 1880, and March 31, 1881, as shown in Table H. The elevation above sea-level is given by Dr. Tyndale[5] as 5,890 feet, and in the United States Chief Signal Officer's Report for 1880 as 5,796 feet. In the Smithsonian tables the elevation of Fort Bayard is put at 4,450 feet. The mean *annual* temperature of Silver City, Dr. Tyndale[5] tells us, is 53·7° F., derived from two years of observation. As the result of *four* years of observation, he gives the following data of mean temperature for each of the twelve months of the year.

MEAN TEMPERATURE AT SILVER CITY.

(Four years of observation, United States Signal Service, quoted by Dr. Tyndale.)

January	37·2	May	61·7	September	63·5
February	41·0	June	70·3	October	56·6
March	47·2	July	71·6	November	39·6
April	48·5	August	68·5	December	39·3

These figures will be found to correspond pretty closely to those for Fort Bayard in Table A. The rainfall and the possible extremes of temperature at Silver City may be assumed to be the same as at Fort Bayard (see Tables B. and C.).

Dr. Tyndale[5] gives the actual number of "clear," "fair," and cloudy days at Silver City as follows:

CLEAR, FAIR, AND CLOUDY DAYS AT SILVER CITY.

(U. S. Signal Service, quoted by Dr. Tyndale.)

	Clear.	Fair.	Cloudy.
1879	246	87	34
1880	230	104	32
1881	222	109	32

The average number of clear days occurring during the winter months (October to May) he gives as 122. The relative humidity data have been already stated (Table E, and remarks following immediately thereafter).

Dr. Parker[2] tells us that Fort Bayard is a very favorite post with officers of the army. Of Silver City he speaks as being "a bright little town," whose "business enterprise is very much in its favor," which is "pretty well supplied with stores," and where "living is not quite so tiresome as at many other places in the Territory." He also quotes a report of Dr. Wilson, U. S. A., which states that phthisis is "almost unknown among the native Mexican population" about Fort Bayard, "notwithstanding their filthy habits," and attributes this immunity to the out-of door life led by the natives and to their being "accustomed to the climate." Dr. Wilson thinks, however, that strangers would "require a certain time for acclimatization." For bronchitis Dr. Wilson considers the climate unfavorable, on the ground that the dry and rarefied air proves irritating and excites cough. "I have also observed," he says, "in even slight cases of catarrh attended with cough, that they are very intractable. I have seen several cases of phthisis, and have one at the present time under my charge, but I have not seen any beneficial results produced by this climate. They have all gone on from bad to worse, and finally died." He also states it as his belief that "it is only in the very early stages of tubercular disease that this or any other climate can exert a beneficial influence. . . ." This unfavorable experience and seemingly rather pessimistic opinion of Dr. Wilson may possibly have been due to the fact of his patients having been soldiers in camp. At all events, his report concerning the native Mexicans suggests a brighter side to the picture; and other statements, favorable to the prospects of New Mexico as a future resort for consumptives in the early stage of the disease, or at least for persons predisposed to pulmonary phthisis, will be made later on in this article.

FORT SELDEN.—Fort Selden "is situated on a sandy basin one and one-half miles from the Rio Grande, in southern New Mexico. Latitude, 32° 25′ N." (Report of Dr. Jessop, U. S. A., quoted by Dr. Parker[2]). This post lies in the so-called "Mesilla Valley," which is thus described by Dr. Thomas A. McParlin, U. S. A.:[3]

"It is between the thirty-third and thirty-first and a half parallels of latitude, is about 70 miles long, from 1 to 6 miles wide, and contains about 280 square miles, embracing the towns of Doña Ana (population, 1,000), Las Cruces (2,000), Mesilla (2,000), and others of less size. The air is mild, snow being very rarely seen,* with a bright daily sunshine in about 360 days of the year. Vegetation dries

* Cf. note under Table D. (H. R.)

rather than rots; meat is cured without salt in the open air; and it presents to the invalid the advantages of a very moderate altitude, varying from about 4,000 feet near the Rio Grande to about 7,000 feet in the high cattle-ranges of the Guadaloupe and other mountains.* The valley is protected by the mountains from the cold winds prevailing from the north."

In support of what he has to say respecting the dryness of this region and of the Lower Rio Grande, Dr. McParlin cites an instance of the mummification of a body buried at Fort Craig, about ninety miles north of Fort Selden. For data of mean temperature, of extremes of temperature, and of rainfall at Fort Selden, see Tables A, B, and C.

Concerning the climatotherapy of Fort Selden, I cannot do better than to quote entire the remarks of Dr. Jessop, as given in Dr. Parker's pamphlet.[2]

"Lung troubles are comparatively rare at Fort Selden, as are all diseases of the respiratory† organs, excepting catarrh, which I prefer to consider separately from bronchitis, as it mostly affects the mucous membranes of the nares, tonsils, and larynx, and, I think, seldom extends even to the trachea. It seems to be produced by the almost constant drifting of the irritating dust peculiar to this region, and few new-comers who are much exposed in the open air escape it. It gradually wears off as they become acclimated. Women, from their in-doors habits, are usually free from it. The native New Mexicans are not at all affected by it. Many of them, however, suffer from a form of bronchitis induced, it is thought, by their peculiar fashion of smoking the cigarita, *i.e.*, by inhaling the smoke into their bronchial tubes and exhaling through their nostrils. The climate of this part of the valley of the Rio Grande will improve and probably tend to the cure of many patients afflicted with commencing phthisis, but only by a residence here, not a sojourn of a few months. I think I am within the mark in stating that it will take from eighteen months to two years to acclimate them. To those in advanced stages of consumption no such benefit can accrue. Added to the annoyance of the dust-storms are the distance from home, and the impossibility of obtaining many of the comforts, and especially the varieties in food, which the sick always crave. The prognosis is extremely serious if diarrhœa be a complication; and here I may observe that all cases of chronic diarrhœa appear to do badly at this post, and that, with my present convictions, I would not suffer, if it could be avoided, a patient laboring under this disease to remain at Fort Selden or any point where the Rio Grande constituted the water-supply. The enervating nature of the climate has doubtless much to do with the ill-success attending the treatment of such patients. As regards chronic bronchitis, I can only speak for New Mexico, and, for that disease, I consider the climate of this region as the best in the Territory."

La Mesilla.—The little town of La Mesilla lies about eighteen miles southeast of Fort Selden, at an elevation of 4,124 feet above sea-level. Its mean temperature for each month of the year, and its annual mean temperature, both derived from five years of U. S. Signal Service observations, are quoted from Dr. Tyndale's paper[5] as follows:

Mean Temperature of Year and of Each Month at La Mesilla.
(United States Signal Service, five years of observation, quoted from Dr. Tyndale.)

January	41.1	May	69.2	September	69.5
February	46.5	June	77.3	October	63.7
March	53.5	July	79.6	November	45.6
April	59.8	August	76.5	December	44.4
Year					60.6.

For range of temperature, see Table F.

In respect to clearness of sky, La Mesilla appears to be slightly inferior to Silver City. As the result of four years of observation (U. S. Signal Service), we present the following data quoted from Dr. Tyndale.[5]

Clear, Fair, and Cloudy Days at La Mesilla.
(United States Signal Service, quoted by Dr. Tyndale.)

	Clear.	Fair.	Cloudy.
1878	208	92	65
1879	252	83	30
1880	191	145	29
1881	161	157	47

The average number of clear days occurring during the winter months (October to May) was one hundred and fifteen. The mean relative humidity (1880-81) has been given in Table E, and other data respecting this important factor of climate have been quoted from Dr. Tyndale. Respecting the degree of shelter against cold winds enjoyed at La Mesilla, I have no information save what may be indicated by the data presented in Table H.

It is not among the places specified by Dr. Tyndale as being especially well sheltered. Dr. McParlin[3] says of La Mesilla that, in his opinion, it "may be considered a very favorable locality for pulmonary invalids."

El Paso.—For information respecting the climatic advantages of El Paso, I am indebted to an interesting paper by Dr. E. W. Schauffler, of Kansas City, entitled "The Climate of El Paso, Texas."*

Some of the meteorological data contained in this paper of Dr. Schauffler's, I have already utilized in compiling the data of Table D., and I shall make further draft upon the paper, quoting it extensively, in what remains to be said concerning the claims of El Paso as a winter health-resort.

El Paso, which "was five years ago a sleepy little settlement under the wing of Fort Bliss, has now become an active, enterprising town of some five or six thousand inhabitants, with much actual business and boundless expectations;" the rapid growth of the town being attributable to its numerous railway connections, as no less than five lines of railway centre at that point.

"The mountain ranges of New Mexico and old Mexico abutting on the river at this point, give variety and beauty to the landscape, and contribute that exhilarating quality of 'mountain air' which, combined with the mild temperature of the winter season, constitutes the charm of the El Paso climate."

"The altitude is 3,760 feet above the sea-level—high enough to be pure and bracing, and yet not high enough to embarrass the heart's action and increase the dyspnœa of those affected with pulmonary complaints.† I found it true with regard to myself, while suffering from a severe attack of bronchitis, and also with regard to others whom I met, that whereas at Las Vegas and Santa Fé . . . we suffered from dyspnœa and had to walk slowly, like confirmed invalids, the descent to El Paso enabled us to walk briskly, and soon made us feel equal to running a foot-race."[1] The soil at El Paso is "sandy and very porous." Dr. Schauffler expresses the belief that El Paso "possesses one of the best winter climates in the United States, while it is at the same time in the near neighborhood of some of our most salubrious summer resorts, such as the Hot Springs of Las Vegas, N. M." He commends El Paso as "possessing many of the requisites of a winter resort for persons suffering from pulmonary complaints. Nor," says he, "is this merely a theoretical conclusion. It is confirmed by the experience of a considerable number of asthmatic, bronchitic, and phthisical patients who have already tested the virtues of this climate. Some of these I met myself during a stay of some weeks last February and March; and with regard to others I was informed by the physicians of the place and the army officers at Fort Bliss." As to accommodations, Dr. Schauffler tells us that "notwithstanding the newness of El Paso, they are very fair," and that "there are several quite large and respectable hotels;" that "there is a good market;" and that "the price of living is not high." As to the character of the water-supply and the quality of the water, I have no informa-

* The Guadaloupe Mountains lie about one hundred miles east of the Rio Grande; the Organ, San Andreas, and Soledad Mountains lie from five to twenty miles east of the river. (H. R.)

* Read by its author at the third annual meeting of the American Climatological Society, and published in the New York Medical Journal of January 22, 1887.

† See, however, under Health Resorts, on page 533 of vol. iii. of this Handbook. (H. R.)

tion. So, too, with regard to the protection against cold winds afforded by the mountains at El Paso, I know nothing; it is likely that some degree of shelter is afforded by the mountains which Dr. Schauffler tells us "abut on the river" at this point.

GENERAL REMARKS.—I have now presented at considerable length the main facts in my possession with regard to the climate of different "sections" of New Mexico, and it remains for me only to "sum up," concluding this article with a few general remarks on the climate and scenery of the Territory considered as a whole, and speaking of its claims upon the attention of the physician as a future sanatory region of the United States. The lofty mountain ranges which are scattered about as off-shoots of the Rocky Mountains in different parts of the Territory, undoubtedly add picturesqueness to the scenery at certain points; at the same time it must be borne in mind that the loftiest mountains in New Mexico lose much of the effect of their height by reason of the general elevation of the country at their bases. The northern part of the Territory is the region of the highest mountains. The mountains "are seamed with great 'cañons,' which also penetrate the higher 'mesas' or table-lands in various places. . . . Between contiguous ranges or spurs of the same range are frequently found 'parks' of great beauty and fertility. These specially abound in the western part of Colfax County."[4] "Water-courses are few and far between. Such creeks as there are, all have their fountain-heads in the regions of eternal snow. The water is clear and supposedly chemically pure, being largely melted snow. . . . Vegetation is as sparse as it is in Northern Colorado, notwithstanding the more southern latitude."[5] This sparseness of the vegetation must detract not a little from the beauty of the landscape in New Mexico, and, in a country which depends so largely upon irrigation for its cultivation, the landscape must lose greatly in charm, although not necessarily so greatly in picturesqueness.

Throughout the Territory the climate is remarkable for its exceeding dryness and for its cloudlessness; and, as a necessary result of these characteristics, we find that the heat of the midday sun is very powerfully felt, and that throughout the year the daily or nycthemeral range of temperature is great, and the monthly and yearly ranges very considerable. A study of the charts published in this article will show that in the northern part of the Territory the summers are cool and the winters cold; while below the thirty-fifth parallel the winters become mild and the summers hot. The nearest approach to equability of climate appears to be made in the southwestern portion of the Territory, the region of Fort Bayard. The cloudlessness and dryness of the climate increase as we proceed from the northern toward the southern border. In regard to wind, I find great lack of really instructive data. Shelter from cold winds, and, indeed, from any winds when likely to be laden with the irritating dust which is complained of by some of the authorities already quoted, is a great desideratum for a health-station in New Mexico; and it is to be hoped that fuller data on this point will be forthcoming. In the accompanying table (Table II) I present certain statistics respecting the wind at four of the stations described in this article, and, for the purposes of comparison, at ten other points variously situated. The figures in the first, fifth, and last columns are copied from, and the data in the remaining columns are deduced from, the "Report of the Chief Signal Officer" for 1881. The period of observation is too short for the conveying of *accurate* information respecting any one station; yet the table possesses an interest for the student of comparative climatology, and its data, so far as they go, indicate a singular freedom from wind during the winter season for the southern portion of New Mexico.

In Dr. McParlin's Report[3] the reader will find an account of electrical phenomena observed in New Mexico. These phenomena were very striking, and call the attention of those specially interested in studying atmospheric electricity as a climatic factor, to New Mexico as a good field for their observations and investigations.

TABLE II.

(Deduced from U. S. Signal Service Report for 1881.)

Name of station.	Total movement in miles during 1880.	Total movement in miles (November, 1880, to March, 1881.)	Direction of wind most frequently observed (November, 1880, to March, 1881.)	Direction of wind second in order of frequency. (November, 1880, to March, 1881.)	Greatest velocity of wind observed (November, 1880, to March, 1881.)	Direction from which wind was blowing when greatest velocity was observed (November, 1880, to March, 1881.)	Number of cases out of a total number of 3 × 30 + 31 + 28 + 31 = 453 observations. (November, 1880, to March, 1881.)
Boston	85,704	42,086	W.	N. W.	44	W. & N.E.	13
New York City	74,642	36,060	W.	N. W.	48	N. E.	2
Philadelphia	92,211	43,561	N. W.	N.	43	E.	6
Charleston	71,821	30,356	N.	W.	32	W.	7
Chicago	74,192	29,788	W.	S. W.	35	N. E.	10
Cincinnati	51,565	24,264	S. W.	N. W.	30	W.	4
St. Louis	90,927	40,096	N.	N. W.	37	W.	4
Denver	52,151	19,371	S.	N. W.	42	W.	1
Little Rock	46,488	24,165	N. W.	N.	30	N. W.	44
San Diego	55,462	21,613	W.	N. E.	35	N. E.	38
Santa Fé	54,882	22,965	N.	N. W.	36	S. E.	93
Silver City	34,342	12,542	N. W.	W.	29	W. & N. W.	101
La Mesilla	21,288	10,058	N.	W.	32	S. W.	195
El Paso	37,155*	19,391	N. W.	W.	32†	W.	83

* No wind data for June, 1880. In June, 1881, the total movement was 3,451 miles. Assuming that it was the same in June, 1880, we should have total movement in 1880 = 40,606 miles.

† November and December, 1880, and January, 1881, no self-register at station.

Despite the qualified commendations of New Mexico as a sanatorium for respiratory diseases which have been quoted—as, for example, under the sections on Fort Union, Silver City, and Fort Selden—it is, nevertheless, a striking fact that both phthisis and any catarrhal affection attributable to the weather, appear to be very rare among natives and acclimated inhabitants of the Territory. Dr. Symington, quoted by Dr. Tyndale,[5] on the authority of "a pamphlet prepared by the railroad companies," says that "in a residence of eight years in New Mexico he had seen but two cases of phthisis among the natives;" and in respect to catarrh we are told, on the same authority, "'Among the troops originally sent to New Mexico in 1861, there were some three hundred and fifty cases of catarrh. At the expiration of a year no cases were reported, and all who had the disease and remained in the country were cured.'"

A Government table, quoted in full by Dr. McParlin,[3] bears out the truth of this statement so far as the years 1861 to 1865 are concerned; *but* during this very period the "total diseases of the respiratory organs" equalled about one in ten of the "mean strength" of the forces. This same table shows that during the period from 1867 to 1876, the mean strength of the force at Santa Fé was 82 men, and that in each year there were treated for catarrh at this post from 0 to 35 soldiers, and for "total diseases of the respiratory organs," from 1 to 38. Catarrh was, therefore, at that time by far the commonest form of disease affecting the respiratory tract; at least such was the case at Santa Fé. On the other hand, only two cases of consumption are reported throughout the whole of this later period (ten years); but both these cases died. The United States Census Report for 1880 shows that during that year there were, within the Territory of New Mexico, only 4.18 deaths from consumption reported for every 10,000 of population; the population being 119,565.

Lack of proper accommodations for invalids has hitherto been a serious obstacle in the way of New Mexico's popularity as a winter health-resort. Food and lodging were both such as mark the frontier. Of late, numerous railway connections have rendered the Territory far easier of access than it was a few years ago; and, now that the country has been thus tied to the larger centres of civilization, it is to be hoped that really good accommodations for the invalid may be established at such points

as shall have been found especially eligible as climatic sanatoria. From data, given by chart and by quoted verbal description in the course of this article, it would appear that the southern portion of New Mexico is the part of the Territory best suited by climate for the winter resort of invalids; and that, with proper food and lodging, and adequate shelter from wind, cases of incipient phthisis and of many diseases of the respiratory system should derive great benefit, or even cure, from a resort thither. The whole Territory, by reason of its wonderful dryness and its general elevation above the sea-level, offers to extreme advocates of the "high-altitude" class of health-resorts an almost unparalleled opportunity for clinical investigation of their claims. Patients with organic lesions of the heart, or with tendency to cardiac complications and symptoms accompanying other forms of disease, should carefully avoid all but the very lowest-lying stations; those who have a decided cardiac lesion or complication had best keep away from New Mexico altogether. These remarks on climatotherapy are intended to apply equally to Arizona; or, at least, to all but the low-lying southwestern portion of that Territory (see article on Arizona). *Huntington Richards.*

[1] Schauffler, E. W., A.M., M.D.: The Climate of El Paso, Tex., N. Y. Med. Journal, January 22, 1887.

[2] Parker, W. Thornton, M.D.: Concerning the Climate of New Mexico, Archives of Medicine, vol. xii., No. 2, October, 1884.

[3] McParlin, Thomas A., Surgeon U. S. Army: Notes on the History and Climate of New Mexico.

[4] Encyclopædia Britannica, vol. xvii., art. New Mexico.

[5] Tyndale, J. Hilgard, M.D.: New Mexico; Its Climatic Advantages for Consumptives, Boston Med. and Surg. Journal, 1883, vol. i., pp. 265 and 313.

NEW ORLEANS. [For an explanation of the chart, headed Table A, and for suggestions as to the best method of using it, see Climate.] The city of New Orleans lies upon the Mississippi River, at a distance of one hundred and seven miles from its place of emptying into the Gulf of Mexico. So tortuous, however, is the course of the river, and so far does its many-mouthed delta extend out into the Gulf, that this distance of one hundred miles is double the distance from the city to the general coast line of Louisiana, when measured "as the crow flies." Moreover, to the north of the city, and only separated from the Mississippi by the narrow and low-lying isthmus upon which New Orleans is built, a great arm of the sea, forty miles long and twenty-four miles wide, extends far into the mainland. This arm or bay of the Gulf of Mexico is generally known under the name of Lake Pontchartrain. A similar salt-water bay, called Lake Borgne, lies to the east of the city, at a distance of only twelve miles. Lagoons of salt or brackish water lie to the southeast and to the southwest of New Orleans; so that the city, so far as its climate is concerned, is almost a city of the coast. The population of New Orleans in 1880 was 216,140. Of its extensive commerce, as the seaport of the Mississippi Valley, it is not necessary to speak in this place; neither do I purpose attempting a description of the city. The accompanying chart, Table A, obtained from the Chief Signal Office in Washington, is introduced primarily for convenience of reference in the case of such readers of the HANDBOOK as reside in New Orleans, or as are by experience familiar with its climate; secondarily, it is intended that its data shall set forth to all readers a type of the climate prevailing along this portion of the Gulf coast. Mr. G. W. Cable, the writer of the article on New Orleans in the "Encyclopædia Britannica," alludes as follows to the climate of the city: "The climate is not marked by extremes of heat or cold. The wide reaches of water and wet lands that lie about the city on every side temper all airs, and the thermometer rarely passes above 95° or below 27° F. The consequent humidity of the atmosphere, however, gives the climate an enervating quality and an apparent warmth and cold beyond the actual temperature. It is rarely invigorating, and during the long summer between June and October is distinctly, though not severely, debilitating; but in the absence of epidemic yellow fever, whose visitations are becoming more and more infrequent, there is no 'sickly season;' and those who visit the city between the months of November and June, the term in which the commercial movement is at its height, may enjoy from as late to as early to its end the delights and beauties of a redundant spring time, and find easy entrance into the social gayeties of a high-spirited, pleasure-loving people." The spring-like weather of the New Orleans winter is, however, interrupted by considerable falls of temperature. During the months of December, January, and February the mean daily variation of temperature is slightly greater than it is at New York City,* although not so great as at Jacksonville, Fla. On comparing the Signal Service charts of New Orleans and Jacksonville (Table A in this article, and Jacksonville chart, on page 234 of vol. iv.) it will be seen that in winter the mean minimum and absolute minimum temperatures of the two places are very nearly the same. In Table B and Table C I have set down the number of days on which certain maximum and minimum temperatures were recorded at New Orleans by the United States Signal Service observers, the data being calculated from tables of daily maximum and minimum temperatures, published in the Reports of the Chief Signal Officer for 1879 and 1880. The winter of 1878–79 was colder than the average at New Orleans, that of 1879–80 was decidedly warmer than the average. The winter rainfall of New Orleans is decidedly heavier than that of Jacksonville, and there is a greater prevalence of wind and a somewhat greater degree of cloudiness of sky at the former than at the latter place. Appletons' "Handbook of Winter Resorts" says that "the climate of New Orleans is more severe in winter than that of corresponding latitudes on the Atlantic coast, owing to the cold north winds," and that "the variations of temperature are too great and too sudden to entitle it to be considered as propitious for invalids." The "low-lying situation of the city—lower than the surface of the river" (which is kept from overflowing by the great embankment known as the levee), according to this same authority, "adds the aggravation of exceptional dampness to its other climatic drawbacks." Owing to the peculiarity of its situation the drainage system of New Orleans is of a somewhat "primitive" character. Mr. Cable (*loc. cit.*) speaks of the drainage as "inadequate and superficial," but tells us (1884) that it is undergoing improvement, and that the sanitary authorities of the city who have the matter in hand are "active." The death-rate of New Orleans is pretty high, averaging, in the three years, 1879–81, 26.52 per 1,000 (Cable, *op. cit.*).

For pulmonary phthisis the climate of New Orleans cannot be recommended. "Consumptives," says the writer in Appletons' "Handbook," "especially those in advanced stages of the disease, should avoid even a brief stay;" and for throat troubles, and pulmonary diseases in general, he also advises against the climate of the city. On the other hand, he admits that of invalids "in the 'weak lungs' and general debility stages of disease," who resort to New Orleans to escape the cold winters of the Northern States, "not a few are benefited by the change."

However little may be said in favor of the city of New Orleans itself as a winter health-station, it seems not unlikely that places in its near neighborhood, along the Gulf coast of Louisiana and of Mississippi, may at no distant day acquire a wide reputation as good winter resorts. Covington, a small town lying some thirty miles to the north of New Orleans, and Pass Christian, on the Mississippi coast, some fifty miles northeast of the city, are both places which belong within this category. In the course of a very entertaining article upon New Orleans which appeared in *Harper's New Monthly Magazine*, for January, 1887, the writer, Mr. Charles Dudley Warner, speaks as follows of these places: "I crossed the lake† one spring day to the pretty town of Mandeville, and then sailed up the Tchefuncta River to Covington. The winding Tchefuncta is in character like some of the narrow

* See article on Colorado Springs, vol. ii. of HANDBOOK, where, in Table F, on page 238, the figures for mean daily range are given.

† Lake Pontchartrain.

TABLE A.

Climate of New Orleans, La.—Latitude 29° 58′. Longitude 90° 4′.—Period of Observations, December 1, 1879, to December 31, 1883.—Elevation of Place of Observation above the Sea-level, 8 feet.

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature as derived from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January	50.7	59.5	54.0	54.7	66.0	48.1	61.2	47.3	78.0	68.0	42.0	20.0	25	28
February	54.0	63.8	57.3	58.3	62.9	55.3	66.1	51.6	80.0	72.0	45.0	32.5	22	20
March	58.6	68.7	62.1	63.1	67.9	58.9	71.7	56.7	84.0	72.5	52.0	36.5	26	23
April	65.7	74.8	68.2	69.5	72.5	65.0	76.6	62.8	86.0	79.0	58.5	38.0	21	23
May	72.6	80.1	75.2	75.3	76.8	72.5	81.8	68.6	92.0	85.0	66.0	56.0	21	24
June	78.9	85.0	79.8	81.0	84.3	79.8	87.2	74.8	97.0	89.0	74.0	65.0	19	27
July	80.5	86.4	81.0	82.6	84.3	80.5	89.0	76.7	96.0	91.0	77.0	69.8	23	23
August	78.9	85.9	80.5	81.7	83.8	79.1	88.1	76.0	96.5	89.0	76.0	69.0	25	26
September	75.2	82.4	76.9	78.1	80.1	73.6	84.5	72.3	92.0	88.0	70.0	58.0	20	22
October	66.8	75.4	69.2	70.4	75.4	66.9	78.1	65.9	88.7	80.0	59.5	40.0	19	23
November	57.3	65.7	60.1	61.0	65.5	56.3	67.8	54.7	82.0	75.0	48.0	31.5	21	19
December	51.9	60.2	54.8	55.6	63.6	47.8	62.9	49.1	78.0	70.0	41.0	20.0	25	25
Spring	.....	.....	.....	69.3	71.6	66.7	....	....	.....	.....	.....	.....	.....	.....
Summer	.....	.....	.....	81.7	83.8	80.3	....	....	.....	.....	.....	.....	.....	.....
Autumn	.....	.....	.....	69.8	72.8	66.9	....	....	.....	.....	.....	.....	.....	.....
Winter	.....	.....	.....	56.5	61.4	52.3	....	....	.....	.....	.....	.....	.....	.....
Year	.....	.....	.....	69.8	71.1	67.4	....	....	.....	.....	.....	.....	.....	.....

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	Miles.
January	58.0	72.2	12.2	7.6	19.8	5.52	N.	7.8
February	47.5	69.3	10.5	8.3	18.8	4.36	S.E.	8.6
March	57.5	70.0	10.6	10.1	20.7	5.75	S.E.	8.6
April	48.0	70.1	10.8	10.6	20.9	6.31	S.E.	8.5
May	36.0	70.1	14.3	10.5	24.8	5.61	S.E.	7.0
June	32.0	72.3	16.0	8.0	24.0	6.04	S.E.	6.0
July	26.2	72.7	17.0	7.8	24.8	6.79	S.E.	5.7
August	27.5	73.0	18.4	7.8	26.2	5.99	S.E.	5.5
September	34.0	72.0	12.9	10.4	23.3	4.39	E.	7.1
October	48.7	71.0	12.0	12.5	24.5	3.41	E.	7.4
November	50.5	71.6	10.2	9.5	19.7	5.58	N.	8.0
December	58.0	72.8	12.0	7.4	19.4	4.85	N.	8.0
Spring	55.5	70.1	35.2	31.2	66.4	17.70	S.E.	8.0
Summer	32.0	72.7	51.4	23.6	75.0	18.82	S.E.	5.7
Autumn	60.5	71.5	35.1	32.4	67.5	13.38	E.	7.8
Winter	60.0	71.4	34.7	23.3	58.0	14.73	N.	8.1
Year	77.0	71.4	156.4	110.5	266.9	65.63	S.E.	7.4

Florida streams, has the same luxuriant overhanging foliage, and as many shy, lounging alligators to the mile, and is prettier by reason of occasional open glades and large moss-draped live-oaks and China-trees. From the steamer-landing in the woods we drove three miles through a lovely open pine forest to the town. . . . The land is elevated a good deal above the coast level, and is consequently dry. The town has a few roomy old-time houses, a mineral spring, some pleasing scenery along the river that winds through it, and not much else. But it is in the midst of pine woods, it is sheltered from all 'northers,' it has the soft air, but not the dampness of the Gulf, and is exceedingly salubrious in all the winter months, to say nothing of the summer. It has lately come into local repute as a health-resort, although it lacks sufficient accommodations for the entertainment of many strangers. I was told by some New Orleans physicians that they regarded it as almost a specific for pulmonary diseases, and instances were given of persons in what was supposed to be advanced stages of lung and bronchial troubles who had been apparently cured by a few months' residence there; and invalids are, I believe, greatly benefited by its healing, soft, and piny atmosphere."

"I have no doubt, from what I hear, and my limited observation, that all this coast about New Orleans would be a favorite winter resort if it had hotels as good as, for instance, that at Pass Christian. The region has many attractions for the idler and the invalid. It is, in the first place, interesting; it has a good deal of variety of scenery and of historical interest; there is excellent fishing and shooting; and if the visitor tires of the monotony of the country, he can, by a short ride on cars or a steamer, transfer himself for a day or a week to a large and most hospitable city, to society, the club, the opera, balls, parties, and every variety of life that his taste craves. The

TABLE B.

Frequency of Occurrence of Various Daily Maximum Temperatures—Winters of 1878–79 and 1879–80.

	December.		January.		February.		Winter of	Winter of
	1878.	1879.	1879.	1880.	1879.	1880.	1878–79.	1879–80.
75°+	0	3	2	3	1	5	3	11
70°–74°	1	10	8	15	6	7	15	32
65°–69°	9	9	6	9	7	4	22	22
60°–64°	4	4	2	1	5	5	11	10
55°–59°	9	1	5	2	6	7	20	10
50°–54°	4	3	3	1	3	1	10	5
45°–49°	1	1	1	0	0	0	2	1
40°–44°	3	0	2	0	0	0	5	0
Absolut. maxima	70°	78°	78°	75°	75°	77°	78°	78°
Lowest maxima	41°	47°	36°*	52°	51°	54°	36°*	47°

* January 5, 1879, maximum only 37°. January 6, 1879, maximum only 36°.

disadvantage of many Southern places to which our Northern regions force us is that they are uninteresting, stupid, and monotonous, if not malarious. It seems a long way from New York to New Orleans, but I do not doubt that the region around the city would become immediately a winter resort if money and enterprise were enlisted to make it so."

From this account I judge that Covington bids fair to become the future Lakewood of New Orleans. Pass Christian probably has not so dry or wind-sheltered a climate as Covington, but may probably be compared to Manhattan Beach or Long Beach set down upon the shore of the Gulf of Mexico, instead of upon that of the North Atlantic in latitude 40°.

As resorts lying in the neighborhood of a great city,

TABLE C.

Frequency of Occurrence of Various Daily Minimum Temperatures — Winters of 1878–79 *and* 1879–80.

	December.		January.		February.		Winter of	Winter of
	1878.	1879.	1879.	1880.	1879.	1880.	1878–79.	1879–80.
70°+	0	1	0	0	0	0	0	1
65°–69°	0	3	1	1	0	3	1	7
60°–64°	0	3	2	12	1	6	3	21
55°–59°	2	5	3	9	2	5	7	19
50°–54°	3	8	5	3	7	5	15	16
45°–49°	9	5	5	5	8	6	22	16
40°–44°	8	3	4	1	6	4	18	8
35°–39°	5	1	4	0	4	0	13	1
30°–34°	3	2	2	0	0	0	5	2
25°–29°	1	0	3	0	0	0	4	0
20°–24°	0	0	2	0	0	0	2	0
Highest minima.	59°	70°	67°	66°	60°	67°	67°	70°
Absolute minima.	27°	32°	20°	42°	38°	43°	20°	32°

and as places which proper management may fit to be, and careful clinical and meteorological observations may *prove* to be, good winter sanatoria for those who cannot escape the severe cold of the Northern United States at that season, they both deserve mention in this place. The water temperatures appended to certain of the charts accompanying the Report of the Chief Signal Officer for the year 1881, show that at Mobile (Lat. 30° 42′ N.) the water in winter is much colder than at Punta Rassa on the Gulf coast of Florida (Lat. 26° 36′ N.), and colder even than it is at Cedar Keys, on the same coast (Lat. 29° 8′ N.), and that, at a depth of 16.8 feet, it varies from 42° F. to 55° F. As Pass Christian is only seventy miles distant from Mobile and only thirty miles farther south, I take it for granted that sea-bathing would be quite out of the question at that place during the winter season.

Huntington Richards.

NEWPORT. The accompanying chart, obtained from the Chief Signal Office in Washington, and representing the climate of the city of Newport, R. I., is here introduced for convenience of reference. A detailed explanation of this chart, and of others similar to it, will be found in the general article on Climate; where also the reader will find suggestions as to the best method of using such charts.

H. R.

Climate of Newport, R. I.—Latitude 41° 29′, *Longitude* 71° 19′.—*Period of Observations, August* 1, 1875, *to March* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 14 *feet.*

	A			AA	B		C	D	DD	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Mean daily range of temp. deduced from Columns C and D.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January	27.8	33.4	29.7	30.3	38.2	26.1	37.7	22.3	15.4	61.5	44.0	15.0	−7.8	20	29
February	29.2	35.2	30.8	31.7	35.3	27.6	39.0	24.0	15.0	56.0	46.0	16.0	−2.0	19	22
March	34.0	39.9	34.8	36.2	40.2	32.0	43.7	29.6	14.1	68.0	48.0	25.5	8.9	25	25
April	42.7	48.6	42.3	44.5	48.3	42.7	50.2	40.8	9.4	69.5	62.0	35.0	22.0	21	22
May	53.6	57.9	51.9	54.4	58.7	49.8	62.3	48.3	14.0	85.2	68.0	40.0	33.0	26	19
June	63.9	68.2	61.3	64.4	67.1	61.4	71.3	56.8	14.5	89.0	79.0	52.0	44.8	19	20
July	69.7	74.2	67.5	70.4	73.2	68.8	74.7	66 0	8.7	92.0	85.0	59.0	53.5	29	26
August	68.2	73.7	67.2	69.7	72.0	68.0	76.3	63.7	12.6	87.0	81.0	61.0	53.0	18	26
September	62.2	67.2	61.8	63.7	66.7	61.1	70.9	58.7	12.2	88.3	76.0	51.0	41.0	21	17
October	52.6	58.0	53.3	54.6	58.0	50.3	62.6	49.0	13.6	81.5	66.0	43.0	30.0	21	21
November	40.6	45.2	41.5	42.4	46.1	38.1	49.3	36.5	12.8	71.2	55.0	27.0	4.0	18	19
December	32.0	36.4	32.9	36.2	40.6	26.0	42.2	28.1	14.1	60.0	48.0	19.0	−3.0	23	27
Spring	.....	.....	.....	45.0	48.1	43.3	....	....	12.5	.....	.....	.....	.....	.....	.....
Summer	.....	.....	.....	68.1	70.2	66.3	....	....	11.9	.....	.....	.....	.....	.....	.....
Autumn	.....	.....	.....	53.5	56.4	50.5	....	....	12.8	.....	.....	.....	.....	.....	.....
Winter	.....	.....	.....	31.9	36.9	28.5	....	....	14.8	.....	.....	.....	.....	.....	.....
Year	.....	.....	.....	49.6	51.0	48.9	....	....	13.0	.....	.....	.....	.....	.....	.....

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	Miles.
January	69.3	74.8	12.2	9.2	21.4	4.38	W.	11.1
February	58.0	74.0	11.9	8.3	20.2	4.58	W.	11.1
March	54.1	72.7	12.5	7.5	20.0	6.50	N.W.	11.1
April	47.5	70.6	11.1	7.8	18.9	4.81	S.W.	9.9
May	52.2	74.3	12.9	8.2	21.1	2.75	S.W.	8.1
June	44 2	76.2	13.6	9.5	23.1	3.28	S.W.	7.1
July	38.5	77.8	13.8	8.6	22.4	3.67	S.W.	6.8
August	34.0	79.6	12.4	9.0	21.4	3.65	S.W.	6.4
September	47.3	79.1	12.4	8.4	20.8	3.10	S.W.	7.7
October	51.5	75.7	10.7	11.0	21.7	3.83	S.W.	9.5
November	67.2	76.0	10.0	8.2	18.2	3.50	W.	11.1
December	63.0	75.2	13.0	8.0	21.0	3.86	W.	11.5
Spring	76.3	72.5	36.5	23.5	60.0	14.06	S.W.	9.7
Summer	47.2	77.9	39.8	27.1	66.9	10.60	S.W.	6.8
Autumn	84.3	76.9	33.1	27.6	60.7	10.13	S.W.	9.4
Winter	69.3	74.7	37.1	25.5	62.6	12.82	W.	11.2
Year	99.8	75.5	146.5	103.7	250.2	47.91	S.W.	9.3

NEW SOUTH WALES. The colony of New South Wales, in Australia, "is bounded by the Pacific Ocean on the east, by Queensland on the north, by South Australia on the west, and by Victoria on the south. It lies between 28° and 38° south latitude, and 141° and 154° east longitude. . . . The superficial area is estimated at 310,000 square miles, or about one-tenth of the whole of Australia;" and the colony "is no less than three times the size of Great Britain and Ireland, and larger than any state in Europe except Russia" ("Encyclopædia Britannica"). The coast line on the Pacific is about seven hundred miles long, and extends in a direction from N.N.E. to S.S.W. Parallel with the line of the coast a chain of mountains, having an average height of 2,500 feet, runs from the northern to the southern boundary of the colony. The highest portion of this range is at or near the southern boundary, close to the confines of Victoria, where Mount Kosciusko, its loftiest peak, attains an elevation of 7,300 feet. The distance from the mountains to the coast is about thirty miles at this southern end of their course through the colony; in the north, close to the Queensland border, they stand about sixty miles back from the coast; and at a point about half-way between these points, and some one hundred miles to the north of Sydney the strip of land intervening between the mountains and the sea attains its greatest breadth, being about

one hundred and forty miles wide. Just back of Sydney itself this width is considerably less, not exceeding seventy five miles. "The crest of this range is in some places narrow; in others it spreads out into a wide tableland. The eastern slopes are somewhat rugged and precipitous, the sandstone especially being deeply fissured by the watercourses; but along the greater part of the coast there is a belt of flat land, generally of great fertility" ("Encyclopædia Britannica"). On their western side the mountains slope down gradually into the great inland basin of Australia. In the article on Melbourne reference has been made to this inland or transmontane portion of New South Wales (*vide* page 708, vol. iv.), and, as the eastern or cismontane part of the colony is also resorted to by invalids (New South Wales and Victoria being the two Australian colonies most in vogue for this purpose), it may interest the reader to have set before him a brief outline or summary of the climatic conditions which are to be found in various parts of the colony. A very full account of the climate of New South Wales is given in Dr. Julius Hann's "Handbuch der Klimatologie," and from this source are derived all the climatic data presented in this article. On page 631 of Dr. Hann's book there is presented a table giving the mean temperatures in January (the midsummer month), in April, in July (the midwinter month), and in October, and also the yearly mean temperature of no less than thirty five stations lying in various parts of the colony. From this table I have selected the data of sixteen places, as set forth in the accompanying chart. The first four stations mentioned

Mean Temperatures in New South Wales, derived from Average of Daily Maximum and Minimum; also, Average Extreme Temperatures. (*Dr. Julius Hann.*)

Name of station.	Latitude.	Longitude.	Elevation above sea level.	Distance from east coast.	Mean temperature.					Average maximum of year.	Average minimum of year.
			Feet.	Miles.	Jan.	April	July.	October.	Year.		
Port Macquarie (20 years)	31° 25′ S.	152° 54′ E.	52	2	73.04	65.66	53.78	63.68	64.04	90.32	26.68
Sydney (17 years)	33° 51′ S.	151° 11′ E.	154	.	71.24	64.58	52.16	62.50	62.78	100.04*	38.84*
Cape St. George (9 years)	35° 12′ S.	150° 45′ E.	170	...	71.06	63.68	51.98	61.16	61.88	97.88	38.66
Two fold Bay (10 years)	37° 0′ S.	149° 59′ E.	108	...	68.72	62.24	50.72	59.72	60.26	92.12	37.76
Richmond River (4 years)	28° 50′ S.	153° 0′ E.	66	28	77.72	68.72	53.78	70.16	67.46	.....	.....
Windsor (14 years)	33° 36′ S.	150° 50′ E.	66	31	72.68	62.96	48.92	63.68	61.70	110.48	26.78
Armidale (10 years)	30° 24′ S.	151° 46′ E.	3,289	81	69.26	56.30	43.34	57.38	56.48	93.20	19.76
Kiandra (5 years)	35° 52′ S.	148° 32′ E.	4,462	87	57.74	44.96	33.08	44.42	45.14	92.66	00.50
Narrabri (9 years)	30° 20′ S.	149° 46′ E.	754	196	84.38	68.54	50.54	70.34	68.54	113.54	28.58
Mudgee (7 years)	32° 35′ S.	149° 35′ E.	1,509	116	77.90	63.14	47.66	61.16	62.42	105.62	27.14
Bathurst (13 years)	33° 24′ S.	149° 37′ E.	2,198	92	71.96	56.84	42.08	57.02	56.84	104.72	19.76
Wagga Wagga (6 years)	35° 8′ S.	147° 24′ E.	.....	159	77.18	60.62	44.96	61.70	60.62	106.52	25.70
Albury (9 years)	36° 6′ S.	147° 0′ E.	558	171	75.74	61.70	44.42	58.64	59.54	111.92	23.54
Deniliquin (13 years)	35° 32′ S.	145° 2′ E.	410	281	75.74	61.88	46.04	60.44	60.62	113.72	26.42
Euston (3 years)	34° 32′ S.	142° 51′ E.	.....	416	83.12	65.84	50.00	66.38	64.76	118.94†	25.70
Wentworth (7 years)	34° 8′ S.	142° 0′ E.	147	471	80.06	64.22	50.54	65.30	64.40	115.16	30.56

* Absolute maximum since 1856 = 105. 26° F. Absolute minimum = 36.86° F.
† Absolute maximum observed during past ten years = 124.52° F.
N.B.—Dr. Hann does not specify the duration of the period of observations from which the average extreme temperatures are derived. I assume that it was the same as that of the period from which were derived the monthly averages. The last two of the seven temperature columns are taken from a table on page 636 of the "Handbuch der Klimatologie;" all the other columns are from a table on page 631.

are given as types of the coast-lying region where the climate is modified by oceanic influences, and where, in consequence, we find the nearest approach to equability of temperature. The two next following stations represent the low-lying region between the sea and the mountains. The two stations Armidale and Kiandra are types of the mountain climate of New South Wales. Kiandra lies in the valley of the Snowy River, about forty miles distant from Mount Kosciusko, and in this region is probably to be found the coldest climate existing in Australia. An absolute minimum temperature of −7.6 F. at Kiandra is mentioned as being of occasional occurrence (by Mr. Russell, Royal Astronomer at Sydney, quoted by Dr. Hann). The stations from Narrabri to Albury represent the western slope of the mountains and the eastern portion of the inland basin. Of the last three stations, Wentworth lies at the junction of the Darling and Murray Rivers, in the southwestern portion of the colony; Euston lies upon the Murray, some sixty miles distant from Wentworth; and Deniliquin lies upon a tributary of the same river, some thirty miles north of the Victoria line. All three stations taken together represent the lower-lying portion of the central basin.

A warm current washes the coast of New South Wales, the temperature of the water in winter being from 5° F. to 8° F. warmer than that of the air (Russell, quoted by Hann). A comparison of the data given in the table for Sydney and for Wentworth, respectively, will, in some measure, demonstrate the equalizing effect of the ocean upon the temperatures along the coast. The extremely high maximum temperatures occurring in the inland portion of the colony might lead the reader to derive an exaggerated idea of the summer heat of that region, did he not observe that the *mean* temperature of January, the midsummer month, is, in every instance, far below the average yearly maximum, and that in no instance is it more than a very little, if at all, greater than the mean of the corresponding month (July) at many places in our own Southern States. The daily range of temperature is everywhere great in New South Wales, greatest of all in the inland region. Such variation is more marked in summer than in winter. At Sydney the nycthemeral range averages only 14.22° F. (7.9 C.), and it is about the same in summer as in winter. At Deniliquin, on the other hand, the mean daily variation throughout the year is 33.5° F.; the mean afternoon temperature in summer is 87.62° F., the mean morning minimum at that season is 53.42° F., giving a mean daily range in summer of 35.20° F. In winter, at this same station, the average daily range is 31.86° F.; the average daily minimum being 28.22° F.; the average daily maximum being 60.08° F. Although not strictly falling under a discussion of the climate of New South Wales, it may, nevertheless, interest the reader to learn that at Alice Springs, a station lying in the very centre of the Australian continent, this same tendency to great variation in the daily temperature, which is characteristic of the climate of all parts of extra-tropical Australia (and especially of the interior) is still noticeable, despite the fact that this station is situated within a quarter of a degree of the Tropic of Capricorn. Thus we are told by Dr. Hann that at Alice Springs the average daily variation throughout the year in 1879 was

30.78° F., and that in the two summer months (December and January) of that year it was 31.50° F.*

The hot winds, or "brick-fielders," described in the article on Melbourne, occur also at Sydney and along the whole east coast of New South Wales; but these winds are far less frequent in occurrence along the east coast than they are along the south coast of Australia. At Melbourne we have seen that they blow on the average nineteen times in the course of the year; at Sydney they occur on the average but three or four times, never oftener than seven or eight times (Russell, quoted by Hann). At Melbourne they are north winds; at Sydney they blow from the northwest. The temperature at Sydney during the prevalence of such a wind varies between 27° C. and 43° C. (80.6° F. and 109° F.), but seldom reaches 38° C. (100.4° F.). An interesting account of the hot winds at Sydney, given by the Royal Astronomer, Mr. Russell, is quoted by Dr. Hann. As a general rule, such a wind begins in the forenoon, lasts but one day, and, on the afternoon of that day, is brought to an end by the occurrence of a violent thunderstorm, known as a "burster," which cools the air very rapidly. Mr. Russell tells us that on such an occasion he has known the thermometer to fall, within fifteen minutes, from 106.88° F. down to 84.92° F.

The prevailing winds along the coast of New South Wales are, in summer, the northeast, southeast, south, and east; in winter, the west, southwest, south, and northwest. Rain comes almost exclusively with winds from the east and southeast; the south wind brings, however, the heaviest single falls of rain. In speaking of these very heavy single falls of rain, Mr. Russell (Hann, *op. cit.*) tells us that on more than one occasion more than 50 ctm. (19⅝ inches) has been known to fall within twenty-four hours. Dr. Hann tells us that it is a characteristic of the rains, both along the east coast of Australia and also in the interior, that they frequently occur in the form of heavy showers. Thus at Sydney, on sixty per cent. of the days on which rain fell, the amount of the fall within the twenty-four hours varied from one-half inch to six inches of water.

With respect to the total amount of the annual rainfall we find that it is greatest along the coast, least in the far inland districts. Thus at Sydney the mean annual rainfall is 50.78 inches, at Cape St. George it is 55.51 inches, at Armidale 29.92 inches, at Bathurst 25.19 inches, at Deniliquin 17.71 inches, and at Euston only 11.81 inches (Hann, *op. cit.*). According to a table given by Dr. Hann, showing the percentage of the total rainfall occurring in each month at various stations, winter is the driest season in the interior; spring the driest season along the coast. The average number of days in the year on which rain falls is about one hundred in the coast region; in the upper half of the interior district it is thirty-nine; in the lower half, sixty-eight (Hann, *op. cit.* pp. 645 and 649). As to cloudiness of sky, we are told by Dr. Hann that the mean annual percentage of cloud along the coast varies from fifty to sixty; that in the interior it varies from twenty to thirty.

Relative humidity figures for New South Wales are not given by any of the authorities whom I have consulted.

Mr. Isaac B. Brown, Jr., late Surgeon Superintendent of H. M. Emigration Service, in his little work on the climate of Australia ("Australia for the Consumptive Invalid: the Voyage, Climates, and Prospects"), pronounces in favor of New South Wales as being the best part of Australia for invalids; but he says that they should not attempt to live in Sydney. The reference to the inland region of New South Wales made in the article on Melbourne (vol. iv., p. 708) will lead an inquirer to such meteorological data from that region as have been presented, by chart and otherwise, in the present article. Lying, as it does, considerably farther north, or nearer to the equator than does the coast region of Victoria, the cismontane or eastern portion of New South Wales is rather warmer in winter, and has a heavier rainfall; but in general it may be said that what holds good for the one region, in regard to climato-therapy, will hold good also for the other (see Melbourne).

Huntington Richards.

NEW YORK CITY. The accompanying chart, representing the climate of the city of New York, and obtained from the Chief Signal Office in Washington, is here introduced for convenience of reference. A detailed explanation of this, and of other similar charts, will be found in the article on Climate; where, also, the reader may find suggestions as to the best method of using these charts.

Data concerning the climate of New York, and not given in this table, may be found in vol. ii., art. Colorado Springs, Table F, on page 238, and Table J, on page 239; also, art. Davos, pages 358 and 359; also, art. Denver, page 404; and in vol. v., arts. Montreal, New Mexico, and Old Point Comfort.

Under the first of these references is given the mean daily range of temperature at New York, and at fifteen other stations; under the second is given the total movement of the wind during the year 1880 at New York, and at twelve other stations. In the article describing Davos the two references are to tables which show, respectively, the sun-temperatures during ten months of 1880 at New York and at Château d'Oex, and a comparison between the atmospheric humidity of Davos and of New York. In the article on Denver will be found a table similar to the one just mentioned, showing the comparative dryness of the Denver and New York City climates. A table roughly illustrating the frequency of occurrence of winds having a velocity of thirty, thirty-five, forty, and forty-five miles per hour at New York City and at Denver during the twelve months June, 1880, to July, 1881, and also showing the actual number of calms recorded at both places *during the year* 1880, stands in the same column with the table of comparative humidities.

There are two errors in this wind-table of Denver and New York City, for which I am to blame, and which I improve this opportunity to correct. The figures 11 and 34 in the last line of the table refer to *observations*, not to days; and the period during which such observations were recorded did not coincide with that specified at the head of the table, but comprised the twelve months of the year 1880.

The Montreal reference is to a table wherein the climates of New York City and of Montreal are contrasted in regard to average temperature (data based on observations covering a number of years), in regard to the percentage of possible sunshine enjoyed during a single year (1882), and in regard to the rainfall, snowfall, and number of days on which rain and snow fell during this same year. The New Mexico reference is to a table setting forth the comparative windiness of New York City and of thirteen other stations during the winter season November, 1880, to March, 1881, inclusive. The Old Point Comfort reference is to two tables showing the relative frequency of occurrence of certain maximum and minimum temperatures at New York City, Boston, and Norfolk, Va. A study of these tables, so far as they go, reveals the fact that difference in latitude does not play an equal part in the modification of climate indicated by the frequency of occurrence of maximum and minimum temperatures respectively.

In proportion to their difference in latitude the Boston and New York climates during the season in question approximate more closely than do the New York and Norfolk climates, so far as concerns maximum temperatures and mean temperatures. On the other hand, so far as concerns the occurrence of minimum temperatures,

* The mean daily maximum in those two months was 103.28° F., while the mean daily minimum was 71.78° F. The extreme summer temperatures of this interior region, and its great yearly range of temperature, are exemplified by an extract made by Dr. Hann from reports of the traveller Stuart. Mr. Stuart observed in the interior of Australia an absolute maximum temperature of 131° F. in the shade (January 21, 1845), and reported that the surface of the ground was so heated, that matches accidentally dropped upon it were kindled immediately—"Zufällig fallengelassene Zündholzchen sich sogleich entzündeten" (Hann, *op. cit.*). On the other hand, in winter he observed a minimum temperature of 24.08° F.

Climate of New York, N. Y.—Latitude 40° 43′. *Longitude* 74° 0′.—*Period of Observations, November* 1, 1870, *December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 35 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January ..	25.4	33.4	29.5	30.1	39.8	25.2	36.7	23.1	64.0	41.0	15.0	—6.0	20	30
February .	28.2	35.2	30.7	33.3	36.3	25.2	40.1	25.9	69.0	49.0	15.5	—4.0	18	19
March ..	36.7	44.1	35.7	36.8	42.8	28.9	45.9	31.3	77.0	53.0	22.0	3.0	24	28
April ..	43.8	51.9	45.2	46.9	56.6	41.3	56.3	40.3	81.0	61.0	40.0	20.0	18	26
May ..	56.0	64.3	56.9	59.0	64.8	53.5	68.5	51.8	94.0	78.0	43.0	34.0	26	23
June	65.8	73.9	66.3	68.6	70.7	64.2	77.1	60.7	95.0	85.5	53.5	47.0	24	26
July	73.2	78.6	71.3	72.7	76.4	71.9	83.7	69.3	99.0	88.0	61.0	57.0	25	16
August....	69.4	77.2	70.2	72.2	75.5	70.6	80.4	64.9	96.0	87.0	63.0	53.0	21	22
September .	62.4	70.2	63.4	65.3	72.2	60.8	74.4	56.5	100.2	70.0	50.0	36.0	24	19
October	52.3	60.3	54.1	55.5	59.8	49.7	65.4	46.7	88.3	71.0	44.0	31.0	21	20
November..	39.7	45.9	40.9	42.1	48.3	37.3	50.9	35.3	74.0	58.0	32.0	7.0	19	20
December..	30.7	35.9	32.3	32.9	40.7	25.1	41.7	28.6	66.2	47.0	22.0	—6.0	19	26
Spring ...	.....	.....	.....	47.5	52.7	41.6	.....	.....	.....	.....	.....	.....	.....	.....
Summer ...	.....	.....	.....	71.5	74.0	70.0	.....	.....	.....	.....	.....	.....	.....	.....
Autumn ...	.....	.....	.....	54.3	59.2	51.7	.....	.....	.....	.....	.....	.....	.....	.....
Winter	.....	.....	.....	31.1	35.8*	27.3	.....	.....	.....	.....	.....	.....	.....	.....
Year ...	.....	.....	.....	51.2	52.9	48.6	.....	.....	.....	.....	.....	.....	.....	.....

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind in miles per hour.
						Inches.	From	Miles.
January ..	70.9	72.4	11.6	7.6	19.2	3.50	W.	9.7
February .	73.0	72.0	10.5	8.0	18.5	3.23	N. W.	10.8
March	69.0	66.6	13.5	7.5	21.0	4.07	N. W.	11.3
April	61.0	64.8	12.4	7.6	20.0	3.25	N. W.	9.7
May	60.0	65.0	13.0	9.7	22.7	2.74	S. W.	8.5
June	48.0	68.9	15.3	7.3	22.6	3.32	S. W.	7.9
July	42.0	70.4	15.5	7.5	23.0	4.46	S. W.	7.5
August ..	48.0	71.1	12.4	9.8	22.2	4.62	S. W.	7.3
September.	64.2	72.8	12.1	8.8	20.9	3.90	S. W.	8.8
October ...	57.3	69.7	12.8	10.2	23.0	3.12	N. W.	9.0
November	67.0	69.6	11.5	8.4	19.9	3.34	N. W.	10.0
December.	72.2	72.4	12.8	6.2	19.0	2.94	W.	10.0
Spring	91.0	65.8	38.9	24.8	63.7	10.06	N. W.	9.8
Summer ...	52.0	70.1	43.2	24.6	67.8	12.40	S. W.	7.6
Autumn ..	93.2	70.7	36.4	27.4	63.8	10.36	N. W.	9.3
Winter	75.0	72.3	34.9	21.8	56.7	9.70	W.	10.2
Year	106.2	69.7	153.4	98.6	252.0	42.52	N. W.	9.2

* N.B.—In the New York chart, as printed in the general article on "Climate," the mean temperature of the warmest winter occurring during the period from November 1, 1870, to December 31, 1883, (Col. B., "winter" line, left-hand subdivision), was given as 33.1° F. This figure in the present chart is corrected to 35.8° F., on the authority of a letter from the Chief Signal Officer, dated February 15, 1887, and sent in reply to a letter of inquiry written February 11, 1887.

there seems to be a greater difference between Boston and New York than there is between New York and Norfolk in proportion to their respective differences in latitude. It would also appear that this greater difference is more marked in the spring than it is in the winter, and that in the spring the New York City climate tends to be decidedly milder than that of Boston. In respect to maximum temperatures in April, the difference between the three places is nearly proportional to their difference in latitude. *Huntington Richards.*

NIEDERBRONN is a small town in Alsace, not far from Strasburg, lying in a valley at an elevation of about 650 feet above the level of the sea.

The accommodations for bathing are rather defective, patients being obliged to take their baths in their own rooms. The season at Niederbronn extends from the middle of May to the end of September. A course of treatment usually occupies about a month.

There are two medicinal springs, one of which has been analyzed by Korsmann, who gives the following proportions:

	Grammes.
Sodium chloride	3.08857
Potassium chloride	0.13198
Calcium chloride	0.79445
Lithium chloride	0.00433
Magnesium chloride	0.31171
Calcium carbonate	0.17912
Magnesium carbonate	0.00653
Ferrous carbonate	0.01035
Calcium sulphate	0.07417
Sodium bromide	0.00072
Manganous oxide	0.01502
Silicic acid	0.00100
Total solids	4.62795

In addition to these appreciable quantities, there are traces of ammonium chloride, sodium iodide, aluminium, and arsenious acid.

The waters are taken internally, and used in the form of baths and douches. They are used in the treatment of scrofulous affections, certain forms of dyspepsia, constipation, obesity, and congestions of the liver, uterus, and other abdominal organs. *T. L. S.*

NIGHTSHADE, DEADLY (*Morelle,* Codex Med.). *Solanum nigrum* Linn.; Order, *Solanaceæ.* A common European weed, growing abundantly in rich waste places. It is a low annual, with branching stems two or three decimetres high, pointed, oval, or deltoid, dentate- or sinuate-bordered leaves, and small, white flowers, with the same structure as those of Dulcamara. Fruit, greenish-black berries, about as large as gooseberries. The whole herb is official. It contains a minute quantity of the alkaloid *Solanine*, which is found in a number of other species of this genus (potato, tomato, dulcamara, etc.), and to this it owes what small activity it has. In spite of its formidable name, Deadly Nightshade is a rather weak drug, and is even used in some places as a potherb, like spinach; climate and soil, however, must have some effect upon it, for it is not always so innocent or agreeable. As a medicine it is not worth notice. If the paralyzing qualities of solanine are desired, the alkaloid itself had best be given. This is, however, very rarely done.

Allied Plants.—See Belladonna.

Allied Drugs.—See Bittersweet. *W. P. Bolles.*

NITRIC ACID, *Aqua fortis.* Under the title *Acidum Nitricum,* Nitric Acid, the U. S. Pharmacopœia makes officinal "a liquid composed of 69.4 per cent. of absolute

Nitric Acid [HNO_3] and 30.6 per cent. of water." Such grade of nitric acid is "a colorless, fuming, very caustic and corrosive liquid of a peculiar, somewhat suffocating odor, and a strongly acid reaction. Specific gravity, 1.420. By heat it is completely volatilized. It dissolves copper with evolution of red vapors, and stains woolen fabrics and animal tissues a bright yellow" (U. S. Ph.). Nitric acid must be kept in glass-stoppered bottles. Nitric acid, although colorless when freshly made and perfectly pure, is more apt, as practically met with, to be of a distinct yellowish shade. It mixes in all proportions with water and alcohol. It is a pretty potent oxidizer, yielding up a portion of its oxygen to oxidizable material, and it has a strong affinity for water, by reason of which affinity, in part, it is powerfully caustic to animal tissues.

The medicinally valuable properties of strong nitric acid are the power of the acid to oxidize on the one hand, and to cauterize on the other. By its oxidizing virtues nitric acid is a serviceable disinfectant in situations where its corrosive action will do no injury; and its cauterant powers are convenient for surgical application. The acid burns searchingly and thoroughly, yet not unmanageably. For application, if it be necessary to carefully limit the area for cauterization, the same should be bounded by a ring of oil or an edge of adhesive plaster, closely applied. The acid is then applied by a glass-rod or bit of stick, care being taken to avoid undue excess. Swallowed in any considerable quantity nitric acid is a powerful corrosive poison, producing effects substantially similar to those caused by sulphuric acid (see Sulphuric Acid). The most striking difference between the poisoning by the two several agents is, that in sulphuric acid corrosion the sloughs tend to be brown or blackish, while in that from nitric acid they are yellow. Inhalation of the fumes of nitric acid may also kill.

In proper dilution nitric acid operates physiologically, as do all the sour mineral acids (see Sulphuric Acid), and shares with hydrochloric acid a sort of selective efficacy in disorders of the digestive apparatus. Vomiting, from many causes, is often effectually relieved by nitric acid, and so is diarrhœa, and so is the functional disorder of digestion commonly ascribed to sluggish action or even congestion of the liver. Even a special curative action over constitutional syphilis has been proclaimed of nitric acid, but is at the present day quite properly discredited. For internal giving, the following preparation of the U. S. Pharmacopœia is to be used:

Acidum Nitricum Dilutum, Diluted Nitric Acid. This preparation is a simple dilution of the officinal strong acid with distilled water, in the proportion of six parts of added water to each one of acid. It represents ten per cent. of absolute nitric acid; is a colorless and strongly sour liquid, non-corrosive but highly irritant. Its specific gravity is 1.059. The internal dose is from twenty to forty drops, largely diluted with water, and the mouth to be well rinsed after the taking of each dose.

Edward Curtis.

NITRITES. Physiological experimentation and clinical testing with a number of different nitrites, both of metallic and ethereal bases, have now developed the fact that such compounds possess certain strongly marked properties in common. These properties evidently belong to the acid radicle of these salts, so that the nitrites are to be regarded as forming a natural group of medicines whose peculiar virtues are due to nitrous acid. The effects wrought by nitrites upon the animal system are, broadly, twofold, as follows: On the one hand, a chemical change in the composition of hæmoglobin, and, on the other, an influence upon nervous and muscular structures, showing itself by profound and, in sufficient dosage, even fatal derangement of function. As regards the effects upon the blood, it is observed that in an animal under the influence of a nitrite the arterial and the venous blood have both acquired in common a peculiar chocolate hue, which does not change when the drawn blood is agitated with air. Examined by the spectroscope such blood shows a replacement of the bands of hæmoglobin by those of a new compound (Gamgee) very probably identical with the *methæmoglobin* of Hoppe-Seyler; and, tested chemically, this changed hæmoglobin is found to have its ozonizing power very seriously [illegible]. Treatment with ammonia restores normal color and [illegible] mal functional power to this nitrite-poisoned blood. The nervous and muscular derangements produced by nitrites are as follows: In moderate dosage there are felt a fulness and throbbing of the head and neck, with almost simultaneous very rapid and disorderly action of the heart, and excited and panting breathing. The face is deeply flushed and feels uncomfortably hot, but the internal general temperature is found by the thermometer to tend to fall. So, too, though the heart and carotids are felt to throb disagreeably hard, yet arterial tension is proved to suffer a very great decline, obviously due to the general capillary dilatation, of which the flushed face is an evidence. In large doses, as observed in animal experimentation, initial great acceleration of the heart's action and violent and hurried breathing are followed by slow, irregular, and failing pulse and respiration, fall of temperature, weakened voluntary and reflex motor activity, and, finally, death by respiratory arrest. As regards the mechanism of these derangements, the initial circulatory phenomena—acceleration of pulse, capillary dilatation and sinking of blood-tension—are mainly the expressions of paralysis, severally, of cardiac inhibition, of resisting power of the muscular elements of the arterioles and, to a less degree, of vaso-motor control over the same. The heart-failure following large dosage is probably due to direct poisoning of the cardiac musculature; the agitated and panting breathing of the earlier stages of the nitrite effect seems to be secondary to the other derangements, but the final arrest of respiration in fatal poisoning appears to result from direct paralysis of the nerve-centres concerned in the function. Similarly, the failure of voluntary and reflex motor power seems to be mainly from paralysis of the motor tract of the cord, although to a certain extent the muscular contractility is itself impaired.

Nitrous acid in combination is thus seen to be an agent that immediately attacks the ozonizing function of the blood and the vital endowments of nerve and muscle-tissues. Many have thought that the paralytic phenomena are probably but consequences of the blood-lesion, but various physiological considerations make it more likely that they result from immediate and independent poisoning of the substance of the nerve-centres.

The principal therapeutic applications of the nitrites are to relieve spasms, or pains referable to spasm, and to arouse the heart in syncope. The most notable instances of the first application are the use of nitrites in the treatment of angina pectoris, spasmodic asthma, and epilepsy. In the first two of these diseases nitrites often prove of astonishing temporary power, but in the last they are, as compared with bromides, second-rate in efficacy. Still, in some cases of epilepsy, where bromides have ceased to impress or where the supervention of bromism has forced their discontinuance, nitrites have shown themselves serviceable alternates (Law). For the relief of syncope nitrites are theoretically indicated where the cardiac arrest is presumably referable to excess of inhibition; and, clinically, the nitrite of amyl has been reported to have restored heart-action in cases of syncope from emotion, from hæmorrhage, and from chloroform-poisoning.

As regards the individual nitrites used in medicine, two only are found in officinal preparations of the U. S. Pharmacopœia, both of them nitrites of ethereal bases, namely, the nitrites of *ethyl* and of *amyl*; but also, though unofficinal, the nitrites of the alkali-metals *potassium* and *sodium* have been experimented with, and, of late, the sodic salt has been considerably prescribed in medicine. Properly also, *nitroglycerin* should be included in a summary of the group of nitrite medicines, since, though not itself a nitrite, there is little doubt that its medicinal effects are wrought by a nitrite resulting from decomposition of the nitro-glycerin within the body. In this place *ethylic*, *amylic*, *potassic*, and *sodic* nitrites will be discussed, nitro-glycerin being treated of under its own title.

Ethylic Nitrite: $C_2H_5NO_2$. Ethylic nitrite, formerly called *nitric ether*, and now *nitrous ether*, is a compound that forms by reaction of nitric acid with alcohol. It is an ethereal fluid of agreeable apple-like flavor and pungent taste—exceedingly volatile, somewhat soluble in water, and more freely in alcohol. Experimented with in the pure condition, this body produces promptly and fully the classical effects of the nitrites as above set forth (Richardson). It is used in medicine, however, only in the form of a weak alcoholic solution—the time-honored and well-known preparation formerly called *sweet spirit of nitre*, but now officinal in the U. S. Pharmacopœia under the title *Spiritus Ætheris Nitrosi*, Spirit of Nitrous Ether. This preparation is made by distilling a mixture of alcohol and nitric acid, and, after purification of the ethereal product, adding enough alcohol to make a spirit containing in solution five per cent. of ethylic nitrite. Spirit of nitrous ether is a "clear, mobile, volatile, and inflammable liquid, of a pale straw-color, inclining slightly to green, a fragrant, ethereal odor, free from pungency, and a sharp, burning taste. Specific gravity 0.823 to 0.825. It slightly reddens litmus paper, but should not effervesce when a crystal of bicarbonate of potassium is dropped into it" (U. S. Ph). It should be kept "in small glass-stoppered vials, in a dark place, remote from lights or fire." Spirit of nitrous ether as found in the shops is apt to be of deficient strength from the fraudulent addition of water or alcohol.

The effects of this spirit are the conjoint effects of its two constituents, alcohol and ethylic nitrite. In the small doses commonly prescribed for medicinal purposes the peculiar nitrite effects are but faintly seen, and the medicine operates as a grateful stomachic, which is at the same time mildly diaphoretic and antispasmodic. The spirit is accordingly much prescribed as an ingredient of so-called fever-draughts or mixtures, its tendency being to ameliorate the discomforts of the febrile state. In large dosage with this preparation the typical nitrite effects are clearly seen—giddiness, headache, and throbbing arteries having been reported as following an overdose, while in another case death occurred from inhaling the fumes from a broken three-gallon jar of the spirit accidentally spilled in a room. Spirit of nitrous ether is prescribed in doses of from 2.00 to 4.00 Gm. (practically from thirty minims to a fluidrachm) several times a day. The dose may be mixed with water for the taking, or prescribed as an ingredient of mixtures containing saline solutions. Such mixtures should not be ordered in quantity beyond present need, since dilution with water tends to set on foot chemical changes in the ethereal spirit. Spirit of nitrous ether is an ingredient of the officinal *Compound Mixture of Glycyrrhiza* ("Brown Mixture") of the U. S. Pharmacopœia.

Amylic Nitrite: $C_5H_{11}NO_2$. Amylic nitrite is used in medicine under its own form, and is officinal in the U. S. Pharmacopœia under the title *Amyl Nitris*, Nitrite of Amyl. It is most conveniently made by distilling a mixture of nitric acid and purified amylic alcohol, and appears as "a clear, pale yellowish liquid, of an ethereal, fruity odor, an aromatic taste, and a neutral or slightly acid reaction. When freely exposed to the air it decomposes, leaving a large residue of amyl alcohol. It is insoluble in water, but soluble, in all proportions, in alcohol, ether, chloroform, benzol, and benzin. Its specific gravity is 0.872 to 0.874, and it boils at about 96° C. (205° F.), giving an orange-colored vapor. It burns with a fawn colored flame" (U. S. Ph.). It should be kept "in small, glass-stoppered vials, in a cool and dark place." Amylic nitrite is excessively volatile, and the utmost care is necessary to preserve a specimen both from loss of bulk and from spontaneous decomposition by exposure.

Amylic nitrite is the nitrite commonly used in medicine for the specific sake of the nitrite effects proper, and it is, perhaps, the most striking of medicines in the matter of rapidity and intensity of action. From its extreme volatility and pleasant odor—very closely resembling that of a ripe banana—the ether is efficiently and conveniently given by inhalation. When the quantity of from three to five drops, poured upon a handkerchief, is inhaled, the subject is conscious, within so short a time as from three to ten seconds, of a sensation of heat, fulness, and throbbing of the face and head, immediately followed by an indescribable and most distressing commotion within the chest, the heart beating fast and furiously, and the breathing being panting and hurried. Giddiness and some muscular languor accompany these phenomena, and perspiration may break out, but in a very few minutes the derangements of function begin to recede, and rapidly, and upon their complete disappearance the subject is left without after-effects, save, possibly, a little dull headache and lassitude, lasting from half an hour to an hour. Assuming such dosing with the ether to have been in a case open to the therapeutic powers of the nitrites, and the therapeutic effect will have been as swift and pronounced as the physiological derangement. No medical relief, indeed, so nearly merits the designation of "as if by magic," as the sudden and complete abrogation of an anginal or asthmatic seizure that is so often wrought by the swift and profound action of amylic nitrite. The drug, however, must not be expected to be infallible, for many cases of angina pectoris, of asthma, and syncope—notably profound chloroform-syncopes—often set the nitrite at defiance.

Amylic nitrite is an important medicine for the conditions enumerated above as being peculiarly amenable to the nitrite influence, and has also proved serviceable in dysmenorrhœa and other affections, painful or spasmodic. The remedy is most conveniently given by inhalation, from three to five drops being poured upon a handkerchief, and the cloth then held to the nose and mouth. Those who are subject to angina or asthma, and who find relief from amylic nitrite, may carry a small vial of the ether about with them, and, upon the occasion of a seizure, themselves dash a few drops upon a handkerchief. Or it may be sufficient to sniff strongly at the opened vial itself until the characteristic sense of flushing and arterial throbbing proclaim the absorption of a sufficiency of the vapor. If a vial be so carried and used, it should be but a small one, not over two c.c. (thirty minims) capacity, since by frequent uncorking of the bottle the contained sample of amylic nitrite gets "flat" and loses its efficacy through chemical change brought about by the exposures to air. More convenient than a vial, both because of better preservation of the medicine and because of combined rapidity, ease, and certainty of dispensing of the dose, are what are commonly called *pearls* of amylic nitrite. These pearls are small, flattened, sealed chambers, blown of very thin glass, and charged with fixed quantities of the nitrite, generally from two to five minims. For use a single "pearl" containing the prescribed dose, is simply crushed in a handkerchief and the fumes of the liberated ether are inhaled in the usual way. The glass of which the pearl is made is so thin that the broken fragments do no harm. These pearls are not officinal, but are quite universally to be procured. Amylic nitrite can, if preferred, be given by the mouth, dropped upon sugar, or dissolved in alcohol, in doses of from two to five drops.

Potassic Nitrite: KNO_2. Potassic nitrite is not officinal in the U. S. Pharmacopœia, and has, indeed, as yet, been used but little in medicine. It is a colorless salt, slightly deliquescent, soluble in water, and occurring in crystals or in fused sticks. Tested upon man and the lower animals, potassic nitrite is found to produce all the typical nitrite effects; but, as might be expected, more slowly, while yet more enduringly, than amylic nitrite. In the experiments of Weir Mitchell and Reichert[1] full doses made themselves felt by symptoms during a period of from one and a half to five hours, beginning within one or two minutes after swallowing. The doses ranged from three to ten grains, single or repeated, and one individual experimented upon took, in divided doses, within a period of six hours and thirteen minutes, thirty-five grains of the salt. But from the behavior of sodic nitrite of ascertained purity (see below), the question cannot but protrude itself, was the sample of the potassic salt used in these experiments tested for purity? In the present condition of knowledge of the subject, the comparatively large quantities cited above

should certainly not be medicinally prescribed for an untried subject.

It does not seem to this writer likely that potassic nitrite will be much used in medicine, since all its valuable effects can be equally well gotten from the more innocent salt—sodic nitrite—described below. Potassic nitrite gives rise, during the period of its action, to eructations of gas of a very offensive phosphuretted odor, so disagreeable as even to lead in some cases to nausea and vomiting (Reichert).

Sodic Nitrite: $NaNO_2$. Sodic nitrite is also an unofficinal salt. It occurs in crystals or fused sticks, freely soluble in water. Commercial samples are rarely pure, being composed of nitrate and nitrite in varying proportions. The better grades may contain 98.5 per cent. of nitrite, but specimens of a salt sold as sodic nitrite have been found to contain but the merest trace of that body —0.011 per cent. only (McEwen). The condition of small crystals, as against that of large transparent crystalline forms or the fused nitrite, is said to be the best for purity. Sodic nitrite deteriorates in keeping—a fact doubtless accounting for the poor quality of the drug so often found.

Sodic nitrite produces the peculiar nitrite effects in a manner generally similar to potassic nitrite, and, when a good sample is employed, can be fatally poisonous, as has been proved by experimentation upon animals. In full dosage with the human subject, extreme distress, and even an alarming condition, have been reported; the prominent complaint being of excessively violent and turbulent heart-action, with great giddiness and general weakness. In such cases lividity of the lips and nails has quite commonly been observed.

Therapeutically sodic nitrite has proved efficient, in the usual way of nitrites, to control the pain in many cases of angina pectoris, and in cases of frequently recurring paroxysms has, in single dose, established freedom therefrom for half a day in subjects to whom amylic nitrite gave immunity for but an hour or two (Matthew Hay). Such immunity, furthermore, was secured by a dosage small enough not to produce any pronounced throbbing or giddiness or headache. In epilepsy this nitrite has also been used with some abatement of the fits; but it is, in a general way, inferior to bromides for this particular therapeusis. From the experience with the salt, so far acquired, sodic nitrite can be said to be available for all the therapeutics of the nitrites, and to have the advantages over the ethereal salts of a more deep-rooted and lasting influence, and of much greater cheapness. On the other hand, as compared with amylic nitrite, the sodic salt is slower in establishing its effects, so that when urgency of relief is demanded the amylic salt is preferable. Sodic nitrite gives rise to some disagreeable eructations of gas, but in therapeutic dosage the occurrence is slight. The *dose* of sodic nitrite should, for a pure sample, not exceed 0.13 Gm. (two grains), for the larger doses of five, ten, and twenty grains that were at first used by investigators have, with good specimens of the salt, produced very distressing and even alarming effects. The effects of a two-grain dose will persist a number of hours. Care should be taken in prescribing this medicine, that the sample is of good quality and not too old. *Edward Curtis.*

[1] American Journal of the Med. Sciences, July, 1880.

NITROBENZENE, POISONING BY. This substance, also called nitrobenzol, is a contribution of organic chemistry to commerce. It is made by the action of nitric acid on benzene (benzol), which is one of the ingredients of coal-tar. The formula of nitrobenzene is $C_6H_5NO_2$; it is a substitution product of benzene. It is a clear, straw-yellow liquid, insoluble in water, and possessing a strong odor, sufficiently like that of bitter almonds to permit of its use in perfumery and confectionery. It has become a rather familiar article of commerce under the name of oil of myrbane. It appears from several recorded cases that small doses of the liquid are poisonous, and even its vapor is active. The symptoms resemble somewhat those of prussic acid, but there is no immediate insensibility and no convulsions. The skin becomes clammy, the lips and fingers purple, the eyes glassy, and the breathing very slow and infrequent. In a case that occurred in the practice of Dr. H. M. Dean, of Muscatine, Ia. (*Medical Bulletin* vol. i., p. 50), violent effects followed the mere tasting the article. The pulse was not much affected, but the respirations occurred at long intervals. The mind usually remains clear for some time, but unconsciousness ultimately ensues. The diagnosis will generally be determined by the powerful and characteristic odor of the substance, which can easily be distinguished from that of both prussic acid and oil of bitter almonds, which it most nearly resembles.

Nitrobenzene is partly converted in the body into aniline, but its poisonous action does not depend on this conversion.

There is no specific treatment; the symptoms must be combated as they arise. Emetics or the stomach-pump may be employed. Dr. Dean, in the case above referred to, used fluid extract of digitalis, one drop every hour, and also, every few minutes, a teaspoonful of a mixture of one part of alcohol and two of hot water. He could make the patient swallow by putting the spoon well back on the tongue. *Henry Leffmann.*

NITROGEN MONOXIDE. Nitrogen monoxide (N_2O), is the body commonly called *nitrous oxide gas*, and formerly popularly known as *laughing-gas*. It is a colorless gas, practically without smell, and with a very faintly sweetish taste. It dissolves in a little more than its own measure of cold water, to a less extent in warm water, and to a less extent still in a saturated aqueous solution of sodic chloride. By combined exercise of cold and pressure the gas can be condensed to the liquid condition, yielding a colorless and very mobile fluid. Upon release of pressure this fluid immediately springs again into the state of gas. Nitrogen monoxide actively supports the combustion of inflammable bodies, undergoing decomposition and yielding up its oxygen to the burning substance.

Nitrogen monoxide is, physiologically, absolutely bland, and being also odorless is perfectly respirable even when substituted, pure, for atmospheric air. When so respired, the gas, from its free solubility in watery fluids, is rapidly absorbed into the blood. If inhaled with admixture of enough atmospheric air for the ordinary needs of the system, nitrogen monoxide proves peculiarly exhilarant. A sort of tingling thrill runs through the nerves down to the very finger-ends, and, if enough of the gas be taken, the experimenter is irresistibly driven to the commission of some extravagant and silly act, almost always such as betokens an uncontrollably joyous state of mind. Singing, shouting, laughing, dancing, and capering are thus the common expressions of the exhilaration—manifestations whence comes aptly the old name *laughing-gas*, applied to a mixture of nitrogen monoxide and air. When inhaled pure, in entire substitution for atmospheric air, the phenomena are (after a very transient initial feeling of the above-described exhilaration) the same as when pure nitrogen is respired, namely, such as result from the respiration of an atmosphere devoid of available oxygen. The blood returning from the lungs ceases to acquire the arterial hue, its free oxygen rapidly diminishes in quantity, the animal speedily loses consciousness, and, if the inhalation be continued, dies by asphyxia, in the same time that it dies in an atmosphere of plain nitrogen, and with a similar reduction of the percentage of free oxygen contained in the blood. These various facts sufficiently prove that at the temperature of the animal body nitrogen monoxide resists decomposition, so that the oxygen of its molecule is unavailable for the purposes to which ordinarily respired oxygen is put.

Nitrogen monoxide inhaled pure is, then, practically an agent that will, without other derangement, produce the unconsciousness of coma from asphyxia, while not interfering with the free play of the lungs in the respiratory act. The clinical phenomena of the inhalation are, *subjectively*, a beginning feeling of the peculiar tingling

and sense of exhilaration noted above, which, however, is soon overwhelmed in swift-rushing unconsciousness. According to the fulness of the respirations the unconsciousness may supervene in from a few seconds to two or three minutes. In a carefully observed experiment the writer of this, practising the fullest possible forced inspiration and expiration, and beginning the inhaling after a forced expiration, was noted to have passed into complete unconsciousness in the middle of the third inspiration. During the continuance of the unconsciousness anæsthesia is absolute; and upon withdrawal of the gas and substitution of atmospheric air the senses are regained as rapidly as they were lost, and in two or three minutes the experimenter is in perfectly normal physiological status again. *Objectively* the phenomena are a swiftly developed lividity of the skin and mucous membranes, staring, and sometimes convulsively rolling eyeballs, a convulsive twitching of the hands, and, when unconsciousness has supervened, a slow, snoring respiration. The pulse is little affected. During the unconsciousness the muscles are, with the exceptions noted above, quite thoroughly relaxed.

Nitrogen monoxide is used as a medicine proper and as an "anæsthetic." Taken in small quantities, so as not to interfere with normal absorption of oxygen, the substance often seems to abate symptoms of nervous debility or exhaustion, and hence to be of value in the treatment of many so-called functional nervous diseases. For such purposes the gas may be given by inhalation, a few whiffs being drawn from a bag through the usual mouth-piece, while at the same time atmospheric air is breathed through the nostrils, purposely left unclosed. Another method of administration is to give an aqueous solution of the gas by swallowing. A patented solution of such character, made under a pressure of five atmospheres, has been used under the title of *oxygenous aërated water*. Nitrous oxide water has but little odor, and is slightly sweetish to the taste. But by far the commonest use of nitrogen monoxide is the administration of the pure gas by inhalation, in order to produce the anæsthesia of unconsciousness. For this administration a bag of a capacity of from four to thirty-two litres (one to eight gallons), according to the proposed duration of the inhalation, is charged with a pure article of the gas, undiluted. From the bag the gas is drawn through a connecting-tube out of a mouth-piece so constructed that by an arrangement of valves the products of expiration pass into the air and not back into the bag, and also that the operator may, by the turn of a switch, admit air and cut off gas at pleasure. The patient's clothing being so adjusted as to offer no impediment to respiration, the mouth-piece is put in place, the nostrils gently compressed by the fingers of the administrator, the stop-cock that controls the delivery of the gas from the bag is turned, and the patient is enjoined to breathe as fully as possible. As soon as full lividity of the face and stertorous breathing proclaim the development of unconsciousness, the patient is ready for operation, and if such operation be one of brief duration, like the opening of an abscess or the drawing of a tooth, the administrator at once removes the mouth-piece as soon as unconsciousness is attained, anæsthesia persisting for a number of seconds after withdrawal of the gas. If the operation be a prolonged one, then, as soon as coma is complete, the administrator, by turning the switch in the mouth-piece, gives a little air, and then again, by a reverse turn, a little gas, and so, guided by the color of the blood as seen through the skin, by the snore of the respiration, and by the presence or absence of voluntary muscular movements, he skilfully gives, alternately, air to keep his patient alive and gas to keep him in practically continuous unconsciousness. In this way a practised administrator can maintain prolonged anæsthesia with nitrogen monoxide; but by the very necessities of the case the patient is always just on the verge of awakening to consciousness of pain on the one hand, and to the undesirable sudden movement of a limb on the other. Obviously, therefore, despite its advantages of swiftness and pleasantness of action, nitrogen monoxide is more appropriate, given in the above manner, as an anæsthetic for momentary than for prolonged operations. In order to secure an easy continuance of anæsthesia, Dr. Paul Bert, of Paris, has proposed the method of administering a mixture of nitrogen monoxide and oxygen under increased atmospheric pressure. Under such circumstances the oxygen of the mixture prevents asphyxia, yet the characteristic anæsthetic unconsciousness of nitrogen monoxide supervenes with the usual quickness and kindliness, and can be continuously maintained without dangerous or even disagreeable effect. Bert mixes the gases in the proportion of 85 parts of nitrogen monoxide to 15 parts of oxygen, and conducts the administration in a special chamber of compressed air representing a total atmospheric pressure of 93 centimetres of mercury. Anæsthesia has thus been safely and pleasantly maintained without break for over an hour, but the large volumes of gas required for such prolonged application and the trouble of providing the compressed-air chamber will probably always seriously interfere with the extension of the method into practice.

Nitrogen monoxide is obtained from the salt *ammonic nitrate* by heating the same in a retort. At an elevated temperature the salt decomposes, and from its constituents water and nitrogen monoxide form (NH_4, $NO_3 = 2\,H_2O + N_2O$). The gas is supplied by manufacturers, condensed to a liquid in strong iron cylinders—a convenient method of storage, since in this way a large volume of gas occupies but a small space. From these cylinders the administration-bag is filled as occasion demands. It is not wise to attempt to make the gas, unless provided with apparatus constructed for the purpose, since, unless the distillation be done in a certain precise manner, the resulting gas may contain dangerous impurities. A pure article of fused ammonic nitrate is to be used; the heat is to be gradually applied and never allowed to exceed 482° F., and the gas, after passing through a series of wash-bottles, one of which contains a solution of potassa, is to be collected in a gasometer, over water, or over an aqueous solution of common salt. *Edward Curtis.*

NITROGLYCERIN. Nitroglycerin, called also *glonoïn*, is, chemically, a trinitrate of the radicle glyceryl, represented by the formula, $C_3H_5(NO_3)_3$, equivalent to the replacing of the three hydrogen atoms of the hydroxyl groups in the molecule of glycerin by the nitro-group NO_2. Nitroglycerin is made by the action of nitric acid upon glycerin, and is a transparent, colorless, dense oily fluid, of about the specific gravity 1.6; slightly soluble in water, but freely soluble in ether or alcohol. It is slightly volatile, inodorous, and of a sweet, pungent, aromatic taste. Upon concussion, as is well known, it explodes with extreme violence. Nitroglycerin is not official as a medicine, but yet has been considerably used as such of late, and, by a consensus of custom, is almost always prescribed in the form of a one per cent. solution in alcohol. Such solution is amply strong enough for medicinal purposes, and is entirely inexplosive.

The effects of a one per cent. solution of nitroglycerin upon the animal system are, in kind, exactly those of the nitrites (see Nitrites), with the additional symptom of a severe and obstinate headache. In rapidity of action, nitroglycerin occupies a position between amyl nitrite on the one hand, and the nitrites of the alkali-metals on the other. The agent is powerful; a single drop of the one per cent. solution taken upon the tongue produces within three or four minutes a transient feeling of cerebral fulness and frontal pain, and a dose of four or five drops quickly determines a full nitrite derangement—flushed face, throbbing arteries, violent and disorderly heart-action, hurried respiration, and splitting headache. Overdosage is extremely dangerous, as shown by a reported case where, after a dose of two and a half drops of a *five* per cent. solution, the typical nitrite effects were quickly succeeded by sickness, faintness, and coma with stertorous breathing. The heart's action became alarmingly weak, but the patient finally recovered.

Nitroglycerin producing thus exactly the effects of a nitrite, the instinctive inference is, that in the career of the compound in the animal economy it suffers change

into a nitrite, and as such nitrite exerts its activity. This subject of a possible chemical conversion of nitroglycerin within the system has been studied by Matthew Hay (*Practitioner*, June, 1883), who finds that nitroglycerin is decomposed by alkalies and alkaline carbonates, with the conversion of two-thirds of its nitric acid into nitrous, which nitrous acid then combines with the alkali to form a nitrite of the same. This reaction, furthermore, Hay was able to produce by treating a one-tenth per cent. solution of nitroglycerin in water with freshly drawn defibrinated blood, and digesting the mixture for forty minutes in an oven at a temperature ranging between 104° and 113° F. Such mixture assumed the peculiar chocolate color of nitrite-poisoned blood, and by analysis, after an hour's digestion, nearly the whole of the nitroglycerin present was found to have undergone decomposition.

Nitroglycerin thus seems to be, for the pharmacologist and physician, but a nitrite-furnishing compound, whose distinguishing feature is solely the extraordinary intensity of its action, a feature which Hay accounts for by the fact that nitroglycerin is, by the peculiarity of its composition, exempt from the decomposition by the acid of the gastric juice to which nitrites are liable—a decomposition which always renders inert a certain proportion of each dose of a nitrite swallowed as such.

The therapeutic applications of nitroglycerin are those of the nitrites. The remedy has been used with benefit in angina pectoris, asthma, and epilepsy, especially in *petit mal*, and also in the anæmic form of migraine (Hammond), and in nephritis attended with a hard, corded pulse (Robson). The dose, in an untried subject, should be at first but a single drop of the customary one per cent. alcoholic solution, to be repeated every fifteen minutes until four or five drops shall have been taken or relief experienced. In habitual use, as for epileptics, the dose will very likely require gradual increase. At the rate of an additional drop per dose each month so large a dosage as twelve drops three times a day of the one per cent. solution has been taken without the production of undue derangement. *Edward Curtis.*

NITRO-HYDROCHLORIC ACID (Aqua Regia). Under the title *Acidum Nitro-hydrochloricum*, Nitro-hydrochloric Acid, the U. S. Pharmacopœia recognizes the product of mixing together four parts of nitric acid and fifteen of hydrochloric. On making such mixture effervescence occurs and a golden-yellow, fuming fluid results, strongly acid and intensely corrosive—more so than the original acids of its composition—and also possessed of the peculiar properties of smelling of chlorine and of readily dissolving gold-leaf. This fluid is wholly volatilizable by heat. As its smell suggests, nitro-hydrochloric acid contains free chlorine, and the more, the more recent the preparation of the sample, since by keeping, especially if exposed to light, the chlorine is constantly tending to undergo conversion into hydrochloric acid, deriving hydrogen by the decomposition of water. Nitro-hydrochloric acid should therefore be made and kept only in small quantities, and these, after all effervescence has subsided, should be put up in glass-stoppered bottles, half filled only, and stored in a cool place, protected from the light. The reaction whereby free chlorine is evolved in a mixture of nitric and hydrochloric acids is now commonly regarded by chemists as the following:

$$HNO_3 + 3HCl = 2H_2O + NOCl + Cl_2.$$

As already said, nitro-hydrochloric acid is intensely corrosive to animal tissues. The acid is possible, therefore, as a surgical caustic, but the more manageable nitric acid is commonly and properly preferred. The special medicinal value of nitro-hydrochloric acid lies in its influence over the functions of the liver, and also over certain obscure derangements of metabolic processes, notably over that leading to considerable appearance of calcic oxalate in the urine—the condition, in short, clinically dubbed *oxaluria*. As regards influence over the liver, nitro-hydrochloric acid has long enjoyed the reputation of tending to abate congestions of the organ, to oppose the march of cirrhosis, and even to favor the limitation of abscess, and, in so-called [illegible] of the liver, to cause recedence of the symptoms. Experimentally, also, Rutherford has shown that th[illegible] possesses considerable cholagogue power. Nitro-hydrochloric acid is therefore a standard remedy for the treatment of oxaluria and the various above-named di[illegible] of the liver. The medicine can be introduced into the system either by baths or by swallowing. For a bath the acid should be diluted in the proportion of 8.00 Gm. of the acid to a litre of water (one fluidounce to the gallon), and the bath taken in a *wooden* tub. Such baths should be about blood-warm, and should be administered daily, or twice a week, according to indications. The duration of the bath will range from ten to thirty minutes, or until a tingling or pricking sensation is experienced. After removal from the bath the skin of the bather should be wiped very dry. Instead of a general bath, a foot-bath or a sponging with a dilution of the acid of the strength already given may be substituted. These external applications are undoubtedly efficient, and an occasionally developed salivation proves beyond question the absorption of the acid when administered in this way. For internal giving the dose is a very few drops—from three to five—diluted, at the time of taking only, with a wineglassful or so of water, and the draught sucked through a glass tube, with subsequent thorough rinsing of the mouth. For prescription internally there is also in the U. S. Pharmacopœia an officinal preparation entitled *Acidum Nitro-hydrochloricum Dilutum*, Diluted Nitro-hydrochloric Acid, consisting of freshly made nitro-hydrochloric acid diluted, after making, with four times its weight of distilled water. The preparation is a "colorless or faintly yellow liquid, odorless, or having a faint odor of chlorine, and a very acid taste and reaction. By heat it is wholly volatilized" (U. S. Ph.). This dilute acid is, medicinally, objectionable, because the mere fact of dilution tends to favor the conversion of the free chlorine of nitro-hydrochloric acid into hydrochloric acid. As actually dispensed and used, this preparation is, therefore, much more likely to be a mere mixture of nitric and hydrochloric acids than the specific chlorine-containing compound represented by a freshly made sample of the strong acid. The dose of the dilute acid may range as high as twenty drops, to be taken in the same manner as a dose of the strong acid,

Edward Curtis.

NOMENCLATURE, PERSONAL. The naming of diseases, operations, symptoms, methods, etc., after those who first describe or invent them, has many obvious disadvantages; yet it possesses at least the merits of brevity and of not connecting the name itself with any theory whatever. It also serves a useful purpose, many times, as a sort of embalming, as it were, of the memories of those who would otherwise sink to undeserved oblivion. This latter thought has been humorously expressed by Dr. Oliver Wendell Holmes: "If a doctor has the luck to find out a new malady, it is tied to his name, like a tin-kettle to a dog's tail, and he goes clattering down the highway of fame, to posterity, with his æolo attachment following at his heels."

It would, of course, be impossible to make any list absolutely complete, and in this article no attempt will be made to give personal nomenclature as it relates to anatomy, pathology, histology, chemistry, materia medica, and instrumental appliances, while in the other departments lack of space compels many omissions.

Abbe's Condenser. A sub-stage illuminator (see vol. iv., p. 776).

Adams's Operation. 1. An operation for the cure of ectropion of lower lid by removing a triangular wedge from the whole thickness of the lid, and uniting the edges of the wound by sutures.

2. An operation for anchylosis of the hip, by passing a narrow bistoury down to the neck of the femur, then introducing a narrow saw and sawing through. Precautions are taken to avoid the entrance of air, and the wound is at once sealed.

3. The fracturing of the nasal septum by means of a

broad, flat bladed forceps, for the cure of deviation; the fragments being then held in place by a clamp until solidified.

Addison's Disease. See Addison's Disease (vol. i., p. 74).

Addison's Cheloid. Morphœa (see vol. ii., p. 77).

Agnew's Method. 1. A method of operating for the cure of hernia (see vol. iii., p. 638). 2. A modification of Vermale's by which elliptical tegumentary flaps are first made and allowed to retract before the muscles are cut through.

Agnew's Operation. The laceration or removal, by means of a stop-needle and hook, of the capsule in secondary cataract (see vol. i., p. 804).

Alanson's Method. Dividing the skin and muscles, in amputating, in the form of a hollow cone (see vol. i., p. 148).

Alexander's Operation. Shortening the round ligaments for the cure of certain uterine displacements, especially retroversion and prolapse.

Alexander-Adams Operation. The same as Alexander's operation.

Alibert's Cheloid. True cheloid, in contradistinction to Addison's cheloid (see vol. ii., p. 77, and vol. iv., p. 266).

Allis's Sign. A relaxed condition of the fascia between the crest of the ilium and the trochanter major, in fracture of the neck of the femur.

Ammon's (Von) Operation. Canthoplasty for the cure of entropion.

Amussat's Method. Torsion of arteries for the arrest of hæmorrhage. He used two forceps, one to draw out and twist the vessel, while the other seized it at a right angle and compressed it to the extent of lacerating its internal tunics.

Amussat's Operation. Lumbar colotomy by transverse incision (see vol. ii., p. 248).

Anagnostakis's Operation. 1. An operation for trichiasis of the upper lid. The offending cilia are included between two perpendicular incisions, and then excised. The wedge of skin between the incisions is then drawn down and united at the corners by sutures.

2. An operation for entropion of the upper lid, in which an incision is made parallel to and near its free margin; a horizontal fold of skin and part of the underlying orbicularis muscle are then exsected, and the lips of the wound united by sutures.

Anger's Method. A method of operating for the cure of hypospadias, by covering the opening by a double thickness of flaps, one flap being taken from each side.

Anel's Operation. Proximal ligation of the artery for the cure of aneurism—Hunter's operation (see vol. i., p. 208).

Antyllus's Operation. An operation for the cure of aneurism by direct incision of the sac and ligation of the artery above and below (see vol. i., p. 207).

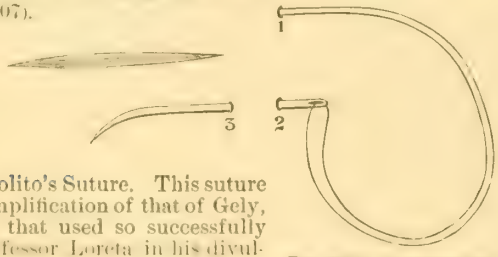


Fig. 2493.—Appolito's Suture. The figures indicate the successive points of exit and entrance of the needle.

Appolito's Suture. This suture is a simplification of that of Gely, and is that used so successfully by Professor Loreta in his divulsive operations on the orifices of the stomach. A single needle is threaded with a double thread, which is knotted over a little ball of aseptic cotton. The needle is passed from within out, beyond the end of the wound and to the side of it (Fig. 2493), the ball being left inside. The needle is then passed to the opposite side, and the first longitudinal stitch made. The subsequent steps are shown in Figs. 2494 and 2495. Before completing the last transverse stitch one thread is cut, so as to leave two ends for tying. When the stitches, one after another, are drawn tight and the wound closed, the line of the wound will present a sinuous fissure. The stitches are carried through all the coats.

Argyll-Robertson's Operation. 1. An operation for relief of entropion of the lower lid, by fastening a sheet of lead inside the lid, so as to produce absorption, by pressure, of the hypertrophic tissue.

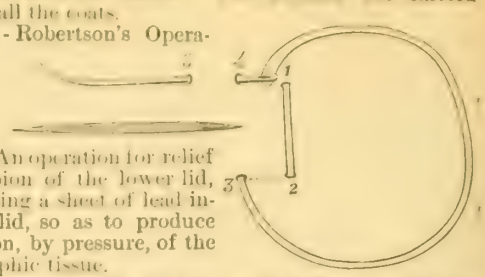


Fig. 2494. Appolito's Suture.

2. An operation for the relief of pain in glaucoma by trephining the sclerotic.

3. An operation for pterygium, in which the growth is separated and excised; the conjunctiva, having been previously dissected up on each side, is then drawn over the wound and its edges united by sutures.

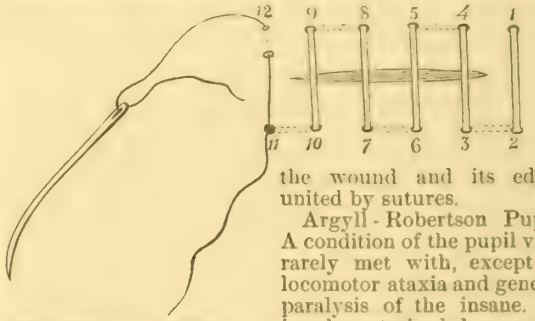


Fig. 2495.—Appolito's Suture.

Argyll-Robertson Pupil. A condition of the pupil very rarely met with, except in locomotor ataxia and general paralysis of the insane. It is characterized by an absence of reflex contraction of the pupil to light, while the associated contraction with accommodation is retained, and vision may be normal.

Arlt's Operation. 1. An operation for the cure of entropion, by forming, and then shifting upward, a bridge of tissue containing the eyelashes.

2. An operation for the cure of symblepharon.

Arlt-Jaesche Operation. An operation for entropion, in which the edge of the lid is slit between the cartilage and the cilia; a narrow strip of skin and underlying muscle is excised parallel to the ciliary border, and one-fourth of an inch above it, and the edges of the wound united by sutures.

Bacelli's Sign (Pectoriloquie aphonique). The reverberation of the whispered voice through a pleuritic effusion. If well marked, it indicates fibro-serous fluid; its absence does not necessarily show purulent pleurisy, but if it disappears during the progress of the effusion it indicates that a fibro-serous effusion has probably undergone a purulent transformation.

Badal's Operation. Stretching or laceration of the infra-trochlear nerve for the relief of pain in chronic glaucoma.

Bader's Operation. The excision of an elliptical piece of the apex in conical cornea.

Bain's Method. A method of performing artificial respiration. The mouth being wiped out and the clothing removed from the upper part of the trunk, the operator, being at the head of the subject, places the fingers of each hand in the axillæ, in their front aspect, with the thumbs on the clavicles, and pulls the shoulders horizontally toward him with a certain degree of force. Upon relaxing his pull the shoulders and chest return to their original state, and the manœuvre is repeated.

Balfour's Treatment. The use of iodide of potassium in aortic aneurism.

Bandl's Ring. A muscular ridge upon the inner surface of the pregnant uterus, concentric with and about six inches above the os externum. This ridge is imperfectly marked before labor, but during and as a consequence of labor-pains it becomes well marked, and defines the limits between the thinned and stretched lower

portion and the thickened and retracted upper portion of the uterus. It is the "pelvic-brim stricture" of Lahs, the "mechanical or clinical os" of Ebell, and the "contraction ring" of Schröder (see vol. iv., p. 355).

Banting's System. A system of dieting for the reduction of corpulency. The following is the bill of fare recommended: For Breakfast—Four or five ounces of beef, mutton, kidneys, broiled fish, bacon, or cold meat of any kind except pork, a large cup of tea (without milk or sugar), a little biscuit, or one ounce of dry toast. For Dinner—Five or six ounces of any fish except salmon, any meat except pork, any vegetable except potato, one ounce of dry toast, fruit out of a pudding, any kind of poultry or game, and two or three glasses of good claret, sherry, or madeira—no champagne, port, or beer. For Tea—Two or three ounces of fruit, a rusk or two, and a cup of tea (without milk or sugar). For Supper—Three or four ounces of meat or fish, similar to dinner, with a glass or two of claret. For Night-cap—A tumbler of grog (gin, whiskey, or brandy, without sugar), or a glass or two of claret or sherry. The alcoholics are not essential, and the number of meals may be reduced if desired.

Barnes's Curve. The segment of a circle having for its centre the sacral promontory, its concavity looking backward.

Barnes's Method. 1. A method of treatment of placenta prævia. (*a*) *Puncture the membranes* or placenta by a trocar, quill, or catheter. This is the most generally efficacious remedy, and can always be applied. (*b*) *Apply a firm binder over the uterus*, to further provoke contractions. (*c*) If hæmorrhage still continue, *tampon the cervix and vagina*. (*d*) If this is not efficient and the os is not yet sufficiently dilated for delivery, *detach the placenta from its adhesion to the lower polar zone*. This is done as follows: "Pass one or two fingers as far as they will go through the os uteri, the hand being passed into the vagina if necessary; feeling the placenta, insinuate the finger between it and the uterine wall; sweep the finger round in a circle so as to separate the placenta as far as the finger can reach; if you feel the edge of the placenta where the membranes begin, tear open the membranes carefully, especially if these have not been previously ruptured. Commonly, some amount of retraction of the cervix takes place after the operation, and often the hæmorrhage ceases." (*e*) If the hæmorrhage does not now cease, *dilate the cervix* by Barnes's hydrostatic dilators, or other means. (*f*) If after dilatation is effected the hæmorrhage continue, *deliver at once;* by the forceps if the head present, otherwise by seizing the nearest leg (preferably by Hicks's method). (*g*) If, after the child is delivered, and pressure has been applied over the uterus, the bleeding continue, *introduce the hand and remove the placenta*.

2. Reduction of uterine inversion by first incising the cervix on each side so as to divide the circular fibres.

Barton's Fracture. A fracture involving merely the posterior lip of the articulating surface of the lower end of the radius.

Barwell's Method. 1. The use of the ox-aorta ligature in aneurism (see vol. i., p. 364).

2. A scarless method of operating on vascular tumors, by passing a needle, armed with silver wire, around the growth subcutaneously, and then tightening the wire.

Barwell's Operation. Ligation of the carotid and subclavian arteries for aneurism of the innominate or aorta.

Basedow's Disease. Exophthalmic goitre.

Battey's Operation. "The complete extirpation of both ovaries, while yet in a state of functional activity, for the effectual remedy of cases of disease otherwise incurable" (see vol. i., p. 479).

Baudens's Amputation. The same as Lisfranc's, except that the head of the second metatarsal bone is retained.

Baunscheidt's Method. A method of applying acupuncture (see vol. i., p. 73).

Baynton's Method. The original method of applying adhesive straps and bandage in the treatment of indolent ulcers.

Beer's Operation. Similar to Daviel's, but made with a Beer's knife and with a smaller flap.

Begbie's Disease. Exophthalmic goitre.

Bell's Disease. Acute peripheral encephalitis.

Bell's Palsy (or Paralysis). Peripheral paralysis of the facial nerve (see vol. iii., p. 22).

Belmas's Method. A method of operating for the radical cure of hernia (see vol. iii., p. 632).

Bigelow's Operation. Litholapaxy (see vol. iv., pp. 511 and 531).

Billroth's Incision. A curved incision, below and parallel with the arch of the inferior maxilla, for amputation of the tongue.

Bischoff's Operation. Very similar to Martin's.

Blandin's Operation. The removal of disks of the nasal septum, by means of an instrument resembling a shoemaker's punch, for the cure of deviation.

Blasius's Operation. An operation for replacing a lower lid with a lid formed of a skin flap taken from the forehead.

Bonnet's Operation. 1. An operation for the radical cure of hernia (see vol. iii., p. 631).

2. The modern operation for enucleation of the eye.

Borelli's Operation. An operation for the cure of staphyloma by transfixing it with two pins at right angles to each other, and then encircling it behind the pins with a thread.

Bosworth's Operation. The removal of obstructing tissue in deviation of the nasal septum by means of delicate saws.

Bowman's Operation. 1. Discission of secondary cataract by means of two needles (see vol. i., p. 804).

2. Trephining the conical cornea.

3. Slitting the canaliculus in order to reach the nasal duct.

Brach-Romberg Symptom. Same as Romberg's symptom.

Brasdor's Operation. Distal ligation of the branches of an artery for the cure of aneurism, all the branches being ligated (see vol. i., p. 212).

Bribosia's Operation. A method of cataract operation in which, as the knife is passed across the anterior chamber, the iris is caused to prolapse upon it, so that iridectomy is made as the incision of the cornea is completed, the capsule having been previously lacerated by a stop-needle.

Bright's Disease. 1. Acute parenchymatous nephritis.

2. Chronic parenchymatous nephritis.

3. Lardaceous disease of the kidney.

4. Interstitial nephritis (see vol. iv., p. 275).

Briquet's Ataxia. Hysterical motor ataxia, characterized by a loss of sensation in both skin and muscles.

Brodie's Knee. Hysterical knee-joint disease.

Browne's Method. Reduction of uterine inversion by first incising the fundus and dilating the inverted cervix through this incision.

Brown-Séquard's Paralysis. Paralysis due to a unilateral lesion of the spinal cord, mainly characterized by motor paralysis and hyperæsthesia on the side of the lesion and anæsthesia on the opposite side.

Bryant's Method. Vertical extension of the legs in the treatment of fractures of the femur in children. Both limbs are flexed at right angles with the trunk, and attached by means of adhesive plaster and cords to some form of a cradle, hook, or bar above the bed; or pulleys and counter-weights may be used. Light lateral splints may then be applied at the seat of fracture.

Bryant's Triangle. The ilio-femoral triangle (see vol. iii., p. 249).

Bryce's Test. A method of determining whether systemic infection has taken place after vaccination. It consists in repeating the inoculation during the evolution of the vaccine disease; if systemic infection has occurred, the second inoculation will mature rapidly, so as to overtake the first, or else fail altogether; if infection has not occurred, the second inoculation will pursue its course in the usual manner.

Buchanan's Method. A method of performing lithotomy (see vol. iv., p. 517).

Buck's Extension. The method of treating fractures

by continuous extension by weight and pulley (see vol. ii., p. 773).

Budd's Jaundice. Malignant jaundice; the "icterus typhoides" of Lebert.

Burow's (Von) Operation. An operation for entropion, on the same principle as the Arlt-Jaesche operation.

Byrne's Method. Reduction of uterine inversion by applying pressure by means of a cup having a false bottom which advances, while counter-pressure is made above by means of a bell shaped cup having a conical plug which serves to dilate the inverted cervix.

Callisen's Operation. Lumbar colotomy by vertical incision (see vol. ii., p. 248).

Cantani's Diet. An exclusive meat diet in the treatment of diabetes.

Carden's Method. 1. The making of a single anterior tegumentary flap in amputating (see vol. i., p. 150).

2. A condyloid amputation of the thigh, in which the flap, taken from the front of the knee, the patella being removed, is turned beneath and attached to the edge of the posterior wound (see vol. i., p. 169).

Carr's Method. A method of treating placenta prævia, by detaching and removing the placenta and then delivering the child as rapidly as possible.

Carswell's Grapes. Pulmonary tubercles, when they occur, by "racemose" distribution, at the extremities of several adjacent bronchioles.

Celsus's Method. Dividing the skin, in amputating by the circular method, retracting it, and then cutting to the bone at the level of the retracted skin (see vol. i., p. 148).

Charcot's Disease. Amyotrophic lateral sclerosis.

Charcot's Joint Disease. The arthropathies of locomotor ataxia (see vol. i., p. 373).

Cheselden's Method. The same as Celsus's method, except that the skin flap is dissected loose from its subjacent attachments and hence increased in length (see vol. i., p. 148).

Cheyne-Stokes Respiration. Consists of a succession of respiratory acts diminishing in force until there is a complete suspension of breathing. This suspension lasts from fifteen to forty-five seconds, when the series begins again with a full inspiration (see vol. ii., pp. 86 and 91).

Chibret's Operation. Establishing corneal drainage in chronic glaucoma.

Chopart's Amputation. Amputation between the astragalus and calcaneum above, and the scaphoid and cuboid below (see vol. i., p. 164).

Clarke's Rule. A rule for dosage of children: Give so much of the adult dose as is represented by a fraction formed by dividing the *weight* of the child, in pounds, by one hundred and fifty.

Cock's Operation. Tapping the urethra in front of the prostate, by thrusting a double-edged knife through the perineum, the finger introduced into the rectum and resting against the prostate serving as a guide to the position of the urethra.

Cohen's Method. 1. A method of inducing premature labor, consisting in passing an elastic catheter between the membranes and uterine wall, and slowly injecting seven or eight ounces of warm water, so as to partially separate the membranes.

2. A method of treating placenta prævia by detaching the smaller flap of the placenta which passes over the os internum to the opposite side from the main body, thus reducing a central to a lateral implantation.

Cohn's Fluid. A culture-fluid (see vol. iv., p. 772).

Cohnstein's Operation. A *proposed* modification of the Cæsarean section by which the uterine incision is to be made in its posterior wall, the uterus having previously been turned out of the abdominal cavity. The uterus, after being evacuated, and contraction having taken place, is replaced, without being sutured, and a drainage-tube is passed through the Douglas *cul-de-sac*.

Colles's Fracture. A more or less transverse fracture of the radius, occurring within an inch and a quarter of its lower end (see vol. iii., p. 248).

Colles's Law. A law of venereal infection. "A child born of a mother who is without obvious venereal symptoms, and which, without being exposed to any infection subsequent to its birth, shows this disease when a few weeks old, this child will infect the most healthy nurse, whether she suckle it or merely handle and dress it; and yet this child is never known to infect its own mother, even though she suckle it while it has venereal ulcers of the lips and tongue."

Copeman's Method. The treatment of severe vomiting of pregnancy by dilatation of the cervix uteri, by the finger, or, if the os is narrow and hard, by bougies.

Corning's Method. The production of local anæsthesia by multiple cutaneous puncture, and the introduction of cocaine by the aid of a galvanic battery.

Corrigan's Button. A firing-iron consisting of a button of iron, half an inch in diameter and a quarter of an inch thick, fastened in a wooden handle by a rod two inches long. The button is heated over a flame until the rod feels warm to the finger, and then applied.

Corrigan's Pulse. The peculiar "jerking," "splashing," "collapsing," or "water-hammer" pulse of aortic regurgitation. It is characteristic and is best observed when the arm is elevated, as in that position the long column of blood, lifted upward by the systole of the heart, quickly falls during diastole.

Courty's Method. Reduction of uterine inversion after the usual method, by effecting counter-pressure by two fingers passed into the rectum and hooked over the mass.

Cowell's Operation. Paracentesis of the vitreous chamber, for the relief of certain forms of glaucoma.

Cowling's Rule. The same as Young's rule, except that the fraction is formed by dividing the child's "age at next birthday" by twenty-four.

Crede's Method. A method of delivering the placenta. As soon as any after-pains have occurred grasp the entire uterus, through the abdominal walls, with both hands, and press it toward the concavity of the sacrum; repeat this *several times*, if necessary, *but only during a pain*, until the placenta is found at the vulva or is entirely expelled. If, from imperfect contraction of the uterus, or from tenderness of the abdominal walls, sufficient pressure to expel the placenta cannot be made, guided by the umbilical cord feel carefully in the vagina for the placenta; if a portion is felt, then, with one hand, make *gentle* traction on the umbilical cord, while with the other pressure is made over the uterus. If the point of insertion of the cord in the placenta cannot be reached, or if on *gentle* traction of the cord resistance is felt, no further effort to deliver the placenta in this way is to be made until after *several uterine contractions* have occurred, which may be increased by *gentle* rubbing and pressure. If the placenta is found low in the vagina, and readily reached by the finger, then pass the index and middle fingers as far upon the placenta as possible and press it gently downward and backward, while with the left hand the cord is made tense. When the placenta appears at the vulva, grasp it with the fingers of one hand and draw it gently upward, and slowly turn it upon itself several times in order that the membranes may form a cord and not be torn away.

2. The instillation into the eyes of newly born infants of one drop of a two per cent. solution of nitrate of silver, as a prophylactic against blenorrhœa neonatorum.

Critchett's Incision. A slight modification of the Graefe incision in cataract extraction.

Critchett's Operation. 1. A method of abscission of staphyloma (see vol. ii., p. 301).

2. Subconjunctival tenotomy in strabismus.

Cruveilhier's Atrophy. Progressive muscular atrophy.

Czerny's Method. A method of operating for the cure of hernia. Expose the sac, separate it from surrounding tissue, isolate its neck, and tie with strong catgut; amputate the sac below the ligature, push up the stump into the abdominal cavity, freshen the borders of the opening, and unite them by continuous catgut suture.

Czerny's Operation. Same as the Sauter operation.

Czerny-Lembert Suture. A suture for closing intestinal wounds. It consists of two rows of stitches; the first row includes the peritoneal and muscular coats, the second is a regular Lembert (see vol. iv., p. 178).

Czerny-Schröder Operation. Same as the Sauter operation.

Daviel's Operation. Extraction of cataract through a large corneal incision downward, without an iridectomy.

Davy's Method. A method of controlling hæmorrhage in hip-joint amputation by means of a lever introduced into the rectum (see vol. i., p. 171).

Del Toro's Operation. Destroying the apex of a conical cornea by means of a white-hot knife.

De Salle, Line of. The *linea nasalis*. It extends from the upper border of the ala nasi downward, in a direction more or less curved, to the outer edge of the orbicularis oris muscle. Is strongly marked in wasting diseases. When this line appears in children, conjointly with that of Jadelot, it is claimed by Peifer to be a positive indication of worms, if a peculiar fixed condition of the eye exist, with pallor of the face.

Desmarres's Operation. Detachment and *transplantation* of pterygium.

Detmold's Method. The arrest of hæmorrhage by the withdrawal of a considerable amount of blood from the circulation, by means of ligatures placed around one or more limbs, just tight enough to arrest the venous return without obstructing the arterial flow.

De Wecker's Incision. A modification of the Graefe incision in cataract extraction.

De Wecker's Operation. 1. A method of cataract extraction without an iridectomy (see vol. i., p. 805).

2. Tattooing leucomata of the cornea.

3. Excision of staphyloma and then closing the wound by uniting the conjunctiva over it.

4. Trephining the cornea in glaucoma.

5. Advancement of Tenon's capsule, and thus of the insertion of the muscle, in strabismus.

Dieffenbach's Operation. An operation for the cure of cicatricial ectropion of the lower lid by dissecting off the affected tissue and replacing it by a healthy flap taken from the vicinity.

Dittrich's Plugs. Soft, friable, smooth masses, of a dirty grayish-yellow color, of very fetid odor, varying in size from a millet-seed to a bean, found in the expectoration of putrid bronchitis, and regarded as characteristic of that affection.

Dolbeau's Method. Perineal lithotrity, a peculiarly constructed dilator being used to dilate consecutively the perineal wound, the tissues to the neck of bladder, and the neck itself. A lithoclast is then introduced and the operation completed in the usual manner (see vol. iv. p. 530).

Dowell's Method. A method of operating for the cure of hernia (see vol. iii., p. 641).

Drummond's Whiff. A sign of aortic aneurism. A whiff proceeding from the glottis, heard in the mouth during expiration, the mouth being open. When the sign is well marked the whiff is audible in the trachea with the mouth shut, but disappears if the nostrils be closed. This sign is of value only when elicited during absolute composure of body and heart, as a similar sound occurs normally after active exercise.

Drysdale's Cell. A cell which, when found in abdominal dropsical fluids, Dr. Drysdale regards as pathognomonic of ovarian disease. "This granular cell is generally round, but sometimes a little oval in form, is very delicate, transparent, and contains a number of fine granules, but no nucleus. The granules have a clear, well-defined outline. These cells differ greatly in size, but their structure is always the same. They may be seen as small as the one five-thousandth of an inch in diameter, and from this to the one two-thousandth of an inch; in some instances I have found them much larger, but the size most commonly met with is about that of a pus-cell. The addition of acetic acid causes the granules to appear more distinct, while the cell is rendered more transparent. When ether is added the granules become nearly transparent, but the aspect of the cell is not changed."

Dubreuil's Method. A method of amputating at the wrist (see vol. i., p. 159).

Dubini's Disease. Chorea electrica, convulsive-cerebral typhus, myelitis convulsiva. An affection in which the convulsive shock of the limbs is very similar to the shock caused by electricity. The disease has been seen in certain districts of Lombardy, and is very fatal.

Duchenne's Disease. Progressive locomotor ataxia.

Duchenne-Aran Type of Muscular Atrophy. A form of progressive muscular atrophy, most commonly found in adults, the atrophy beginning in the upper extremities, and extending.

Dugas's Test. A test for dislocation of the shoulder. If the hand of the affected side is made to clasp the opposite shoulder, the elbow cannot be made to touch the front of the chest.

Duplay's Method. A method of operating for the cure of hypospadias by covering the opening by a double thickness of flaps, two flaps being taken from each side and united in the median line.

Dupuytren's Contraction. A disease of the fingers due to contraction of the palmar aponeurosis (see Fingers, vol. iii., p. 159).

Dupuytren's Method. A method of amputating at the shoulder-joint (see vol. i., p. 162).

Duroziez's Murmur. A double murmur, heard almost exclusively in aortic insufficiency, when the stethoscope is placed over the femoral artery; the first sound comes from the passage of the systolic blood-wave, the second comes from the abnormal backward wave.

Ehrlich's Method. A method of staining tubercle bacilli (see vol. iv., p. 764).

Ehrlich's Solution. A stain for micro-organisms (see vol. iv., p. 763).

Emmet's Method. Reduction of uterine inversion by grasping the body in the hand firmly, and then immediately expanding the fingers so as to put the tissues around the cervix on the stretch, while the hand above aids in dilating the cervical ring. If only partial reduction can be secured, the lips of the os are stitched together over the fundus.

Emmet's Operation. 1. An operation for the cure of laceration of the cervix uteri, by paring the edges of the rent and then uniting them by sutures.

2. An operation for lacerated perineum, in which are reunited the torn fibres of the pelvic fascia.

Estlander's Operation. Exsection of portions of one or more ribs, for the cure of the pleuro-cutaneous fistulæ of empyema.

Everbusch's Operation. An advancement of the tendon of the levator palpebræ superioris, for the relief of congenital blepharoptosis.

Farrant's Solution. A solution for the microscopical examination of fresh tissues (see vol. iv., p. 779).

Fergusson's Method. 1. The method of curing aneurism by manipulating the tumor, so as to detach a fragment of fibrin or old clot which shall plug up the efferent artery (see vol. i., p. 212).

2. The method of exposing the superior maxilla by two incisions: One longitudinal, extending from the inner angle of the eye to the outer limit of the orbit parallel with and a little below the infra-orbital ridge; the other commencing at the nasal extremity of the first and extending downward along the side of the nose, around its ala to the median line, and thence down to the middle of the lip (see vol. iv., p. 244).

Fergusson's Operation. An operation for closing a cleft of the hard palate (see vol. ii., p. 182).

Fleury's Method. Compression of an aneurism by flexion of the limb (see vol. i., p. 212).

Forbes's Amputation. An operation similar to Chopart's, except that the scaphoid and posterior portion of the cuboid are retained.

Forster's Method. A method of artificial ripening of cataract (see vol. i., p. 799).

Fothergill's Face-ache. Trigeminal neuralgia.

Frank's Operation. A modification of the Cæsarean section. The uterus is evacuated in the usual way, except that it is turned out of the abdominal cavity before being incised. A drainage-tube is then passed through the uterus and vagina, its other end hanging out at the lower angle of the abdominal wound. The uterine wound is then sutured above the drainage-tube, with strong catgut, and *the round ligaments brought together and sutured*

and the abdomen closed, so as to shut off the utero-vesical pouch from the general peritoneal cavity and *make a pocket around the uterine incision*, which has been made as low down as possible. This pocket is drained by a tube passing into the vagina in front of the cervix, and a third tube extends along the entire uterine wound.

Freund's Operation. Hysterectomy by abdominal section (see vol. iii., p. 802).

Friedlander's Method. A method of staining the pneumococcus (see vol. iv., p. 675).

Friedreich's Disease. Hereditary locomotor ataxia—the family form of locomotor ataxia. This disease is regarded as a variety of locomotor ataxia. It appears early in life in several children of the same family, and there is always to be found some neuropathic vice in the immediate ancestry. It is incurable.

Fritsch's Operation. Posterior colporrhaphy, especially suitable for extreme degrees of rectocele.

Gaffky's Method. A method of staining the bacillus of typhoid fever (see vol. iv., p. 765).

Gagnele's Method. Subcutaneous ligation of the veins, in operating on varicocele, by silver wire twisted on metal buttons.

Galezowski's Method. A method of extracting cataract. Except that a Graefe knife is used, the corneal incision is essentially the same as in Wright's method; but as the point of the knife passes across the anterior chamber, it is depressed to the lower border of the previously dilated pupil and made to divide the capsule by a sweeping movement to the upper border of the pupil. The remaining steps of the operation possess no peculiarity. If the iris protrude after the escape of the lens, it is replaced with a silver probe.

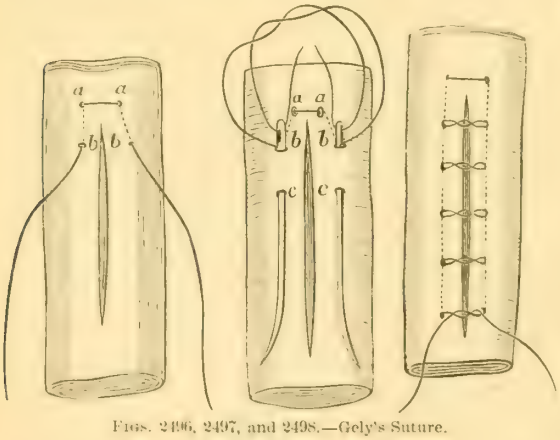
Galezowski's Operation. 1. Synectomy by means of a needle with a cutting edge.

2. An operation for the cure of pterygium, by turning the apex under the base.

Gant's Incision. An incision backward from the angle of the mouth, on one or both sides, for amputation of the tongue.

Gant's Operation. Subtrochanteric section of the femur for anchylosis of the hip.

Gely's Suture. A suture for closing intestinal wounds. A thread is used having a needle on each end. These



Figs. 2496, 2497, and 2498.—Gely's Suture.

needles are passed from without inward, and out again, leaving the threads as shown in Fig. 2496, *a*, *b*. The needles are then passed to the opposite sides, the threads being crossed in a single knot, and passed as shown in Fig. 2497, *b*, *c*. The completed suture, ready for tightening and tying, is shown in Fig. 2498.

Gerdy's Operation. An operation for the cure of hernia (see vol. iii., p. 635).

Giacomi's Method. A method of staining the syphilis bacillus (see vol. iv., p. 765).

Giampetro-Lowenberg Method. A method of introducing the Eustachian catheter. The catheter is passed until it reaches the pharynx, when the beak is turned so that it points horizontally toward the tube of the opposite side; the instrument is then drawn out until the beak catches on the posterior edge of the septum, when it is rotated in the opposite direction, through an arc of at least one hundred and eighty degrees, into the mouth of the tube which it is desired to reach.

Gibson's Operation. The removal of a soft lens through a small corneal incision.

Gioppi's Operation. An operation for cataract, in which the lens in its capsule is extracted with a spoon-like instrument, through an incision similar to Graefe's.

Gouley's Method. A method of operating for the cure of hypospadias, by covering the opening by a fold of skin drawn from behind forward.

Graefe's Operation. 1. Extraction of a cataract through a sclerotic incision, with iridectomy and laceration of the capsule (see vol. i., p. 801).

2. The production of an ulcer at the apex of a conical cornea.

3. An operation for trichiasis, in which vertical incisions are made as in Diellenbach's operation, the remaining steps being very similar to Arlt's.

4. An operation for ptosis, in which a portion of the orbicularis is removed, the effect being to cause a subcutaneous shortening of the lid and to weaken the action of the orbicularis, thus assisting the levator.

5. An operation for staphyloma by the production of suppurative choroiditis and consequent atrophy of the globe.

Graefe-Romberg Operation. Division of the supra-orbital nerve for the relief of blepharospasm.

Gram's Method. A method of staining (see vol. iv., p. 764).

Grancher's Sign. An auscultatory sign of pulmonary consolidation; consisting in the raised *pitch* of the expiratory murmur, which comes to equal that of inspiration.

Grave's Disease. Exophthalmic goitre.

Green's Operation. An operation for entropion, combining the essential principles of the Arlt-Jaesche and Anagnostakis operations, but whose characteristic feature is that the sutures are made to include the upper border of the tarsus and the tendon of the levator.

Green's Test Types. A slight modification of Snellen's.

Gritti's Method. A condyloid amputation of the thigh, in which the patella, having had a slice sawed off its under surface, is attached to the sawn extremity of the femur.

Guerin's Method. Encasing the stump, after amputating, in a dense mass of cotton, as a permanent dressing.

Gussenbauer's Suture. A suture in which, by the use of a single thread, the same result is secured as in the Czerny-Lembert suture (see vol. iv., p. 178).

Hall's (Marshall) Method. A method of performing artificial respiration (see vol. i., p. 378).

Hancock's Amputation. A modification of Pirogoff's, whereby a transverse section is made of the astragalus, the upper portion retained *in situ*, and the sawn surface of the retained portion of the calcaneum (sawn as in Pirogoff's) attached to it.

Hancock's Operation. Intra-ocular ciliary myotomy, for the relief of glaucoma.

Hay's Method. The treatment of pleuritic and other effusions by the administration of concentrated solutions of saline cathartics, and the restriction of fluid ingesta.

Hayem's Fluid. A fluid used in the microscopy of blood (see vol. i., p. 583).

Heaton's Method. A method of operating for the cure of hernia (see vol. iii., p. 634).

Heberden's Disease. A disease closely resembling, if not identical with, rheumatoid arthritis. It was described by Heberden under the title "Digitorum Nodi," as consisting of little knobs, about the size of peas, situated upon the ends of the fingers. They remain during life, but cause little or no pain and but slight inconvenience. He thought they had no connection with gout; with which opinion Dr. Begbie does not agree.

Hebra's Prurigo. Congenital prurigo, of a severe form. Incurable.

Hegar's Operation. 1. Posterior colporrhaphy; very similar to Simon's.

2. The same as Battey's operation.

Hegar-Tait Operation. A misnomer for Tait's operation.

Herzenstein's Operation. An operation for trichiasis, especially applicable in the partial forms. A ligature is passed subcutaneously around the roots of the offending cilia, and allowed to cut its way out, thus destroying the cilia.

Hesse's Apparatus. An apparatus for air-analysis (see vol. iv., p. 773).

Heubner's Disease. Syphilitic disease of the cerebral arteries (see vol. i., p. 627).

Hewson's Dressing. An application of dry earth, containing about fifty per cent. of clay, to wounds, tumors, etc. (see vol. ii., p. 623).

Hey's Amputation. The same as Lisfranc's, except that the projecting portion of the internal cuneiform is sawed off.

Hicks's Method. A method of performing bimanual version, especially adapted to the treatment of placenta prævia. As soon as possible one or two fingers are introduced into the uterus, the hand being in the vagina, and podalic version accomplished by the aid of the other hand used externally. A leg is then seized and brought down, and sufficient traction employed to keep the half-breech in the os as a tampon. If the placenta is in the way, the fingers are passed up at its margin, if this can be reached; otherwise, the placenta is to be perforated. Delivery is allowed to take place naturally, aided only by such traction as may be necessary to keep up proper pressure of the child against the os.

Hilton's Method. A method of opening deep-seated abscesses, or those in close proximity to important structures. Cut through the skin and superficial fascia, push a grooved director into the abscess, and along the groove pass a pair of dressing-forceps; the opening of the forceps while *in situ* will enlarge the opening made by the grooved director and secure thorough evacuation of the pus.

Hirschberg's Operation. An operation for the cure of detachment of the retina, by a paracentesis of the sclera over the seat of the effusion.

Hodgkin's Disease. Pseudo-leucocythemia (see vol. iii., p. 691).

Hodgson's Method. Ligation of the femoral artery at the apex of Scarpa's triangle.

Holt's Method. The treatment of urethral stricture by rupturing, or splitting, by means of an instrument consisting of two grooved blades fixed in a divided handle, and containing between them a wire welded to their points; down this wire, after the instrument is passed into the urethra, is forced a tube, which separates the blades and thus ruptures the stricture.

Hotz's Operation. An operation for entropion, containing the same principle as Anagnostakis's operation, but more of the orbicularis muscle is removed and the sutures are carried higher up, so as to include part of the fascia tarso-orbitalis.

Horner's Method. A method of operating for the cure of salivary fistula, by making an opening through the cheek with a shoemaker's punch, including the fistulous tract, and then closing the external wound by sutures.

Howard's Method. A method of performing artificial respiration (see vol. i., p. 379).

Humphrey's Operation. An operation for amputation of the penis, by which the urethra is dissected loose from its attachments to the stump of the corpora cavernosa, drawn through a slit made at the base of the scrotum on the under side, and attached to the margins of the slit so as to make an artificial meatus in the perineum.

Hunter's Method. Ligation of the femoral artery in the aponeurotic canal.

Hunter's Operation. Proximal ligation of the artery for the cure of aneurism: Anel's operation (see vol. i., p. 208).

Hutchinson's Teeth. Peculiarly deformed upper incisors, of the permanent set; regarded by Mr. Hutchinson as pathognomonic of hereditary syphilis. He describes them as "usually short and narrow, with a crescentic and vertical notch in their edges, and their corners rounded off. Horizontal notches or furrows are often seen, but they, as a rule, have nothing to do with syphilis."

Inman's Myalgia. Pain in the muscles, of any origin.

Jacksonian Epilepsy. Convulsive seizures, in the beginning limited to a part of the body, most frequently the fingers of one hand, sometimes one side of the face, or one foot. At a later period the convulsive movement may affect the whole of one side, or even the entire body. It is often a sign of an irritative lesion—tumor—in the opposite side of the brain, in its motor area.

Jacob's Ulcer. Rodent cancer of the face.

Jacobson's Operation. A cataract operation, in which the flap is made below, the lens removed in its capsule, and that part of the iris bruised in its extraction is drawn out and excised.

Jadelot, Line of. The *linea oculo-zygomatica*. It extends from the inner angle of the eye downward and outward, passing across the face below the malar bone. Is said to indicate, in children, a cerebral or nervous affection; in adults, genital disease, masturbation, or venereal excess.

Jenks's Method. Denudation of the surface, in ruptured perineum, by means of scissors introduced at the lower edge close to the integument, and made to dissect off the surface without being withdrawn, so that hæmorrhage is confined to the point of entrance of the scissors. The detached tissue is finally snipped off and the wound closed.

Jobert's Operation. An operation for the radical cure of hernia (see vol. iii., p. 632).

Jobert's Suture. A suture designed for closing transverse wounds of the intestines. The intestine at the site of the wound having been placed in the position of intussusception, sutures are introduced as shown in the cut; *A* representing the upper, and *B* the lower portion of the intestine.

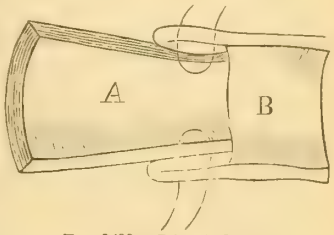


FIG. 2499.—Jobert's Suture.

Jones's (Wharton) Operation. An operation for the cure of ectropion of the lower lid, by making a V-shaped incision through the skin, and then so uniting its edges as to make it Y-shaped.

Kaateer's Method. A method of staining tubercle bacilli (see vol. iv., p. 764).

Kammerer and Giacomi's Apparatus. An apparatus for air-analysis (see vol. iv., p. 774).

Keen's Sign. The increased space that exists between the malleoli, in fracture of the fibula, owing to the tilting in of the upper end of the lower fragment and consequent projection of the lower end.

Kehrer's Operation. A modification of the Cæsarean section. The abdominal incision is made the same as usual, but the incision into the uterus is *transverse*, and at the internal os. This wound is closed by deep and superficial sutures. Drainage-tubes are passed into the vesico-uterine pouch, and into that of Douglas. The other steps of the operation are as usual.

Knapp's Method. A method of performing abscission in staphyloma (see vol. ii., p. 301).

Knapp's Operation. 1. A modification of Critchett's for staphyloma.

2. A modification of Teale's operation for symblepharon.

3. A modification of Desmarres's operation for pterygium; the corneal portion of the pterygium is excised, and the remainder divided into two parts, one being transplanted under the conjunctiva above the wound and the other below.

Koch's Apparatus. An apparatus for air-analysis (see vol. iv., p. 773).

Koch's Method. A method of demonstrating the tubercle bacillus (see vol. iv., p. 793).

Kocher's Incision. An incision extending along the anterior border of the sterno mastoid muscle, from the level of the lobule of the ear to the level of the hyoid bone, along this bone to the median line, and thence to the symphysis menti; for amputation of the tongue.

Kopp's Asthma. Laryngismus stridulus.

Küchler's Operation. An extraction of the lens in its capsule, through a horizontal corneal incision, without an iridectomy.

Kussmaul's Coma. One of the forms of diabetic coma; acetonæmia (see vol. i., p. 58, and vol. ii., p. 254).

Kussmaul's Disease. Acute inflammation of the anterior gray horns: acute atrophic spinal paralysis.

Laennec's Cirrhosis. Cirrhosis of the liver.

Landolt's Operation. An operation whereby a portion of the upper lid is taken to replace a lost lower lid.

Landry's Paralysis. Acute ascending paralysis. The loss of power usually begins in the legs, where it soon becomes pronounced; it then passes upward, affecting the trunk and arms, and finally the muscles of deglutition and respiration. The bladder and rectum are not affected, and sensation is usually unimpaired. It is almost invariably fatal, and usually terminates within two weeks.

Langenbeck's Method. 1. The making of bi-musculotegumentary flaps in amputating, by cutting from without inward (see vol. i., p. 150).

2. Division of the superior maxillary nerve in the spheno-maxillary fossa, by means of a long tenotome passed into the fossa along the outer wall of the orbit.

Larrey's Method. A method of amputating at the shoulder-joint (see vol. i., p. 162).

Lebrun's Operation. 1. A modified Liebreich, the incision being entirely corneal and upward (see vol. i., p. 805).

2. An operation for entropion, similar to that of Anagnostakis, but the portion of skin and muscular tissue excised from the upper lid is larger, and the sutures emerge higher up in the superior flap.

Lefort's Operation. The formation of a median vaginal septum, by partial union of the anterior and posterior vaginal walls, for the relief of prolapsus.

Lembert's Suture. A suture for closing intestinal wounds. The needle is entered on the outer surface of the intestine, about one-sixth of an inch from the edge of the wound, and brought out again half-way between the point of entrance and the edge, without having perforated the mucous membrane; it is then passed in a similar manner on the opposite side, as shown in the figure. After introducing as many sutures as are deemed necessary, they are tied and cut short. This suture can be made continuous, if desired, something like the glover's.

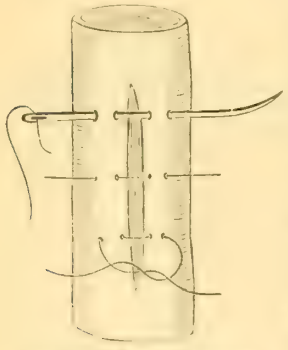


Fig. 2540.—Lembert's Suture.

Lente's Operation. Incision of the rectum, for stricture, in the median line anteriorly and posteriorly.

Leroy D'Etiolles's Method. A method of operating for the cure of hernia (see vol. iii., p. 637).

Levis's Method. 1. Tying the ligature, in ligating varicocele, over a piece of rubber tubing, so as to maintain the tension of the thread.

2. The injection of twenty drops of pure carbolic acid into the tunica vaginalis testis, after the withdrawal of the fluid, for the radical cure of hydrocele.

Liebreich's Operation. 1. A modification of Graefe's, in which the incision is made downward, and is almost entirely corneal, while the lens is removed without iridectomy (see vol. i., p. 805).

2. An operation for strabismus, in which the conjunctiva and sub-conjunctival tissue are separated widely from the sclerotic, and a suture is used to close the conjunctival wound and thus prevent sinking of the caruncle.

Lignerolles's Amputation. An amputation of the foot, by which the astragalus is preserved *in situ*.

Lisfranc's Amputation. Amputation through the tarso metatarsal articulation (see vol. i., p. 164).

Lisfranc's Method. A method of amputation at the shoulder-joint (see vol. i., p. 162).

Lister's Method. 1. A method of employing antiseptics in surgery (see vol. i., p. 257).

2. Excision of the carpus, through two longitudinal incisions along the radial and ulnar borders of the wrist.

Liston's Method. The method of exposing the upper jaw by an incision extending from the angle of the mouth to the external angular process of the frontal bone.

Little's Disease. Spasmodic tabes of children.

Littre's Operation. 1. Left iliac colotomy, the opening being made into the sigmoid flexure (see vol. ii., p. 248).

2. The operation of enterotomy.

Lizar's Method. The method of exposing the upper jaw by cutting through the cheek by an incision extending from the angle of the mouth to the malar bone.

Löffler's Method. A method of staining (see vol. iv., p. 764).

Löffler's Solution. A stain for micro-organisms (see vol. iv., p. 763).

Loreta's Method. The insertion of small wire into the sac for the cure of aneurism.

Loreta's Operation. Digital divulsion of the pylorus.

Louis's Angina. Ludwig's angina.

Ludwig's Angina (Angina Ludovici). An acute suppurative inflammation of the connective tissue around the submaxillary glands. After a few days of prodromal symptoms, the neck becomes swollen and painful. By the fourth day the condition is serious; the tongue is swollen and immovable, there is great salivation, the neck is so swollen that the mouth can hardly be opened, and the line of the chin is obliterated. Great dyspnœa may be caused by pressure on the trachea. The temperature continues high. The disease runs its course to suppuration, or gangrene, in about a week. The disease proves fatal in a considerable portion of cases.

Ludwig's Angle (Angulus Ludovici). The angle which exists, in some cases of emphysema, between the manubrium and the body of the sternum.

Luke's Method. Making the first flap, in amputating, by Langenbeck's method, the second by Vermale's.

Lustgarten's Method. A method of staining the syphilis bacillus (see vol. iv., p. 765).

Macewen's Method. A method of preparing animal ligatures. To one ounce each of water and glycerine, add twelve grains of chromic-acid crystals. In this steep the ligatures ten days, then remove and thoroughly dry them. For preservation, keep them in a five per cent. solution of carbolic acid.

Macewen's Operation. 1. Excision of a V- or wedge-shaped piece transversely from above the internal condyle of the femur, for the cure of knock-knee (see vol. iv., p. 317).

2. An operation for the radical cure of hernia. The bowel being reduced, an incision is made over the external ring. The sac is then separated by the finger from the canal and the cord, and the peritoneum separated for about half an inch around the internal ring. A thread is next fastened to the bottom of the sac, and passed upward, back and forth through the sac, so as to throw it into folds as the thread is drawn tight; the free extremity of the thread is finally brought out above the internal ring and attached to the abdominal fascia, the skin being drawn up so as to operate through the original incision. By this manœuvre the sac, folded into a species of compress or pad, is placed over the internal ring, where it will become adherent. The canal is now closed as follows: By means of a curved needle attached at a right angle to its handle, a thread is passed through the conjoint tendon, the needle penetrating the tendon near its lower border and emerging at a point as high as possible on the inner aspect of

the canal. The thread being seized and the needle withdrawn, the conjoint tendon is held by a loop; each end of this loop is next passed, by another needle having a curve opposite that of the first, at corresponding points through the structures of the transversalis and internal and external oblique muscles; the two free ends are now drawn tight and tied. By this means the natural, valve-like relation of the parts is restored. Other stitches are to be inserted lower down as needed, and the external wound closed *secundum artem*.

Mackenzie's Method. Taking the flap from the inner and plantar surface of the foot and ankle, in making a Syme amputation.

Macnamara's Operation. The removal of the lens in its capsule, without an iridectomy, through a large corneal incision outward.

Malgaigne's Amputation. Subastragaloid amputation of the foot (see vol. i., p. 165).

Manec's Method. The formation of a long anterior, and a short posterior flap in amputating at the hip-joint.

March's Disease. Exophthalmic goitre.

Mariotti's Spot. That portion of the fundus of the eye corresponding to the entrance of the optic nerve, which the well-known experiment of Abbe Mariotti has shown to be devoid of sight.

Marson's Theory. That the degree and duration of vaccinal protection are proportionate to the perfection of the vaccine lesions and to the number of insertions made.

Martin's Operation. Posterior colporrhaphy, by which the normal elevation of the posterior vaginal wall is preserved.

Martino's Operation. Excision of a triangular piece of the auricle for the cure of hypertrophy.

Mason's Method. The method of keeping the fragments in proper position, in fracture of the nasal bones, by the insertion of needles, which are allowed to remain *in situ* for about a week.

Maury's Operation. An operation for the cure of exstrophy of the bladder.

McDowell's Operation. The removal, by abdominal incision, of cystic ovaries.

Meckel's Diverticulum. A diverticulum of the ileum, arising from one to three feet above the ileo-cæcal valve, representing a portion of the unobliterated omphalo-mesenteric canal. It is frequently attached to the umbilicus by a solid cord, and constitutes a band around which twisting of the intestines may occur (see vol. iv., pp. 151 and 175).

Ménière's Disease. A neuropathic form of aural vertigo (see vol. i., p. 430).

Michell's Method. The after-treatment of cataract operations in a light room, and with light dressings to the eyes.

Mikulicz's Operation. "Osteoplastic resection of the foot." It consists essentially in a resection of the lower ends of the tibia and fibula with the whole of the astragalus and calcaneum, and the posterior portion of the cuboid and scaphoid bones, followed by placing the cut surfaces of the scaphoid and cuboid bones in contact with those of the tibia and fibula, and closure of the wound. The approximated bones may be sutured (Haberern) if necessary.

Millar's Asthma. Thymic asthma; spasm of the glottis.

Miner's Method. Enucleation of an ovarian tumor when removal cannot be effected in the usual way, owing to absence or shortness of pedicle, adhesions, etc.

Miquel's Bulb. An apparatus for air analysis (see vol. iv., p. 774).

Moore's Method. A method of dressing, in Colles's fracture, by a small roller and a strip of adhesive plaster (see vol. ii., p. 500).

Mooren's Operation. An operation for cataract similar to Jacobson's, but the iridectomy is made several weeks before the extraction.

Morgan's Method. A method for reducing dislocation of the hip. A foot is placed between the thighs and against the perineum, to effect counter-extension; extension and rotation are made by assistants, from a band attached above the knee, the limb being adducted, the foot becomes a fulcrum and presses the bone off from the pelvis.

Muller's Operation. Same as Porro-Muller operation.

Naegele's Pelvis. The anchylosed, obliquely contracted pelvis (see vol. iv., p. 336).

Nageli's Fluid. A culture-fluid (see vol. iv., p. 772).

Neelsen's Solution. A stain for micro-organisms (see vol. iv., p. 763).

Nélaton's Line. A line drawn from the tuberosity of the ischium to the anterior superior spine of the ileum (see vol. iii., p. 249).

Nélaton's Method. 1. A method of operating for the cure of epispadias, by covering the opening by double flaps, one being turned down from the abdomen, the other brought up from the scrotum.

2. Suspending the patient by the legs, to counteract the hypothetical cerebral anæmia of too profound anæsthesia.

Nélaton's Operation. Enterotomy (see vol. iv., p. 179).

Neuber's Tubes. Decalcified bone drainage-tubes.

Neugebauer's Operation. The same as that subsequently described by Lefort and best known by his name.

Noeggerath's Method. Reduction of uterine inversion by commencing the operation by indenting the fundus at one or the other horn.

Noyes's Operation. 1. An operation for the formation of an artificial pupil in cases of inflammatory secondary cataract.

2. A plastic operation for the cure of entropion.

3. An operation for the advancement of the elongated tendon in strabismus.

4. An operation for secondary cataract, in which a hole is made in the obstructing membrane with a Graefe knife, and then enlarged by tearing it with two hooks passed through opposite corneal incisions.

Nussbaum's Narcosis. The condition of prolonged anæsthesia produced when the administration of chloroform is preceded a few minutes by the hypodermatic injection of a full dose of morphia.

O'Dwyer's Method. The method of treating laryngeal stenosis by intubation (see vol. iv., p. 419).

Ogston's Operation. 1. An operation for the cure of flat-foot, by removing portions of the contiguous surfaces of the scaphoid and astragalus, and then fastening the surfaces together by ivory pegs or wiring, so as to restore the arch. Or the contiguous surfaces of the internal cuneiform and scaphoid may be treated in the same way.

2. Sawing obliquely through the internal condyle of the femur, for the cure of knock-knee (see vol. iv., p. 317).

Pacini's Method. A method of performing artificial respiration. The subject being stripped of clothing from the chest and the mouth wiped out, the operator standing or kneeling at the head of the subject, takes hold of the shoulders by applying his thumbs in front of the heads of the humeri, and the fingers behind and close to the armpits. He then pulls the shoulders toward him, and lifts them in a perpendicular direction, thus enlarging the thoracic cavity transversely and antero-posteriorly. The shoulders are then replaced and the manœuvre repeated.

Pagenstecher's Operation. 1. An operation for the relief of ptosis, by bringing the occipito-frontalis to act upon the lid.

2. The removal of the lens in its capsule, a large iridectomy having been made (see vol. i., p. 808).

3. An operation for pterygium; the pterygium is separated from the cornea and sclerotic, and turned back; the edges of the conjunctival wound are brought together with sutures, and the pterygium sinks and disappears.

Paget's Disease. An eczema-like disease of the nipple and areola, which sometimes precedes cancer of the breast. It has the appearance of a florid, intensely red, raw surface, very finely granular, as if nearly the whole thickness of the epidermis were removed, or like the surface of a very acute diffused eczema, or like that of an acute balanitis. There is always a copious, clear, yellowish, viscid exudation (see vol. ii., p. 411).

Pancoast's Method. 1. A method of operating by injection for the cure of hernia (see vol. iii., p. 634).

2. A method of amputating at the knee-joint, by which a short, oval flap is made anteriorly, including the patella, and two latero-posterior flaps, which join in the middle of the popliteal region.

3. A modification of Levis's, by introducing a button between the skin and rubber.

Parkinson's Disease. Paralysis agitans.

Parson's Disease. Exophthalmic goitre.

Parry's Disease. Exophthalmic goitre.

Passavant's Operation. An operation for division of posterior synechiæ by means of a delicate forceps introduced through a corneal incision.

Pasteur's Fluid. A culture-fluid (see vol. iv., p. 772).

Peaslee's Operation. Superficial trachelotomy. This is a less serious operation than that of either Emmet or Sims. It is performed with a two-bladed metrotome, by which either os, or both, can be incised. Dr. Peaslee regarded the operation as indicated if the external os would not admit a sound of one-sixth inch diameter, or the internal os one of one-seventh inch diameter.

Perier's Operation. Removal of the inverted uterus by the elastic ligature.

Petersen's Bag. A rubber bag, with a capacity of about fifteen ounces, to be inserted into the rectum, and then distended so as to elevate the bladder in the operation of supra-pubic cystotomy.

Petit's Method. The same as Cheselden's.

Pirogoff's Amputation. A modification of Syme's amputation, by which the posterior portion of the calcaneum is preserved and applied to the sawn ends of the tibia and fibula (see vol. i., p. 166).

Pirogoff's Method. A method of operating for the radical cure of hernia. (see vol. iii., p. 632).

Politzer's Method. A method of inflating the middle-ear. A rubber bag having a nose-piece is connected with one nostril, while the other is closed by the finger. The patient is then directed to swallow, or to "hack" or "hick," and at the same instant the bag is compressed sharply, when air will be forced through the Eustachian tubes. In the case of children too young to follow directions the act of crying is taken advantage of in the same way (see vol. ii., p. 578).

Pope's Operation. An operation for trichiasis similar to the Arlt-Jaesche operation, but in addition the tarsus is all removed, except the upper border.

Porro's Operation. Utero-ovarian amputation as completive of the Cæsarean section. After evacuating the uterus, as in Cæsarean section, it is constricted at a point corresponding to the internal os by a rubber band, clamp, or special constrictor, and all the uterus above is cut away. The stump is attached at the lower angle of the abdominal wound, and the case treated as after hysterectomy.

Porro-Muller Operation. A modification of the Porro operation. The uterus is turned out of the abdominal cavity before being incised and the abdomen protected from the entrance of fluids. The uterus is also constricted *before* being incised, so as to prevent hæmorrhage.

Porro-Veit Operation. A modification of the Porro operation. The stump, after removing the body of the uterus, is ligated and dropped, as in ordinary hysterectomy.

Pott's Boss. The projecting spinous process usually found in cases of Pott's disease.

Pott's Disease. Inflammatory destruction of the bodies of one or more vertebræ, or of the intervertebral cartilages, or of both, producing posterior angular curvature.

Pott's Fracture. A fracture of the fibula, within two or three inches of its lower end, accompanied by more or less laceration of the internal lateral ligament of the ankle and a consequent partial dislocation (see vol. iii., p. 253).

Pott's Gangrene. Senile gangrene.

Pray's Test Letters. Letters composed of lines running in different directions for testing astigmatism.

Prince's Operation. 1. An operation for advancement of the tendon in strabismus.

2. An operation for pterygium similar to Knapp's modification of Desmarres's operation, except that the corneal attachment is severed with an instrument shaped like a strabismus hook, but having a sharp point and a concave cutting edge.

Quincke's Pulse. A symptom of aortic insufficiency, consisting of a marked blanching of the finger-nails at each diastole of the heart.

Ravaton's Method. Making a circular incision down to the bone in amputating, and then from this cutting directly upward on each side, so as to make symmetrical flaps.

Raynaud's Disease. Symmetrical gangrene. "A neurosis characterized by an exaggeration of the excito-motor power of the cord in presiding over the vaso-motor centres," as shown by vascular spasm, venous or arterial, in symmetrical parts of the body. The phalanges are usually the parts affected. The local asphyxia may be partial, producing merely a temporary ischæmia, cyanosis, or erythema, or it may be so complete and continued as to produce absolute gangrene. The spasm lasts from a few seconds to several days. The parts affected may be anæsthetic or hyperæsthetic, or the seat of severe pain. Hysterical symptoms may precede or follow the attack. The duration of the disease varies from ten days to several months, and relapses usually occur. But two fatal cases have been reported. Treatment has been thus far of no avail (see vol. iii., p. 300).

Reeves's Method. A method of preparing the tubercle bacillus. In Sputum: Place a little of the sputum, with a needle, on a glass slip; cover with a No. 1 or No. 2 covering-glass, and press the two between the thumb and finger so as to secure a uniform layer. Slide the cover over the edge of the slip and remove with forceps *by pulling*, so as to maintain the uniform layer of sputum. (If too much sputum adheres, or too irregularly, repeat the process.) Place the cover on blotting-paper, sputum side up, for a few minutes, to dry, and then whip it two or three times through the flame of a spirit-lamp. It is now ready for the *first stain*. This is prepared by thoroughly shaking together aniline oil, 1½ drachms, and alcohol, 3 drachms, and gradually adding thereto distilled water, 5 ounces 6½ drachms; after standing a few hours a little of this aniline water is filtered into a watch-glass, and about twenty drops of "Beck's Double Stain"* added, and thoroughly stirred with a glass rod. Into this stain drop the cover, sputum side down, and protect the whole with a bell-glass. If a speedy examination is desired, the stain containing the cover must be subjected to a temperature of 115° to 120° F. for fifteen or twenty minutes; but otherwise the cover should remain in the stain for several hours at the ordinary temperature. After removing from the stain, *decolorize* by immersing in the following acid-wash: Nitric acid, 10 drachms; distilled water, 15 drachms; alcohol (ninety-five per cent.), 25 drachms. After decolorizing wash in distilled water. It is now ready for the *second stain*, which may be an aqueous solution of vesuvin or Bismarck brown, or methyl blue. This contrast stain should not be too deep. After the second staining wash the cover-glass in distilled water, dip in absolute alcohol, dry, clean with benzole, and mount in balsam and xylol.

In Tissue: This requires an extremely thin and evenly cut section, which should be immediately placed on the slide and there handled until the mount is finished.[1] The *first stain* must be in a wide-mouth bottle to receive the slide, which must remain immersed, at ordinary temperature, for twelve to twenty hours. The remaining steps are as above. In all tissue-mounts the sections, before being put into the stain, should be passed from absolute alcohol.

Reid's Method. 1. A method of reducing dislocations of the hip by manipulation (see vol. ii., p. 504).

2. The use of the Esmarch bandage and tube in the treatment of aneurism (see vol. i., p. 211).

* This stain can be obtained of any microscopal dealer.

Rigal's Suture. The ordinary twisted suture, except that little rubber rings are substituted for the threads.

Rigg's Method. A method of curing hernia by means of a seton (see vol. iii., p. 639).

Rindfleisch's Method. A method of staining tubercle bacilli (see vol. iv., p. 764).

Riverdin's Operation. The transplanting of small skin grafts to replace loss of tissue (see Wolfe's Operation).

Roberts's Pelvis. The anchylosed, transversely contracted pelvis (see vol. iv., p. 336).

Robin's Fluid. A fluid used in the microscopy of blood (see vol. i., p. 583).

Romberg's Symptom. The swaying of the body when the eyes are closed, as seen in locomotor ataxia.

Rosenthal's Test. A test for commencing vertebral disease, made by placing one pole of a faradic battery in contact with the front of the body, and passing the other pole down the centre of the vertebral column, when, if any inflammatory lesion exists, pain will be developed at the seat of the change. (An uncertain test.)

Roser's Method. The method of operating on the respiratory passages with the head pendant, so as to prevent the flow of blood into the trachea.

Roussin's Fluid. A fluid used in the microscopy of blood (see vol. i., p. 583).

Saemisch's Operation. An operation for the cure of corneal ulcer by cutting through the cornea at the seat of the ulceration.

Sanger's Operation. A modification of the Cæsarean section. The peculiar features of this operation are as follows: The uterus is, if possible, turned out of the abdominal cavity. Before being incised, its lower segment is compressed either manually or by clamps or Esmarch's tube. After evacuation and contraction, a utero-vaginal drainage-tube is inserted, the peritoneum dissected loose from the edges of the uterine wound and *turned in between the lips of the wound*, and the wound then closed by deep and superficial wire or silk sutures; the deep sutures include the peritoneal and muscular coats, but not the mucous; the superficial stitches are numerous and include only the peritoneum. As originally performed, the edges of the uterine wound, after freeing the peritoneum, were pared away; but this is unnecessary as the peritoneum is sufficiently abundant (see vol. i., p. 738).

Satterthwaite's Method. A method of performing artificial respiration (see vol. i., p. 380).

Sauter's Operation. Kolpo-hysterectomy (see vol. iii., p. 804).

Sauter-Recamier Operation. Same as the Sauter operation.

Sayre's Operation. 1. Subperiosteal excision of the hip-joint. The incision is made with a strong knife down to the bone, commencing midway between the anterior superior spinous process of the ilium and the top of the trochanter major, continuing in a curved course upon the bone to the top of the trochanter, midway between its posterior border and centre, and terminating by being carried forward and inward, the incision being from four to six or eight inches long. The incision must be carried through the periosteum. Draw apart the soft parts, and make an incision at right angles to the first, and through the periosteum only, about an inch below the top of the trochanter. With an elevator peel off the periosteum, lifting the head from the acetabulum as necessary, and divide the bone just above the trochanter minor.

2. Inter-trochanteric Osteotomy. The removal of a disk of bone from between the femoral trochanters, having its upper surface convex and its lower surface flat. The upper end of the shaft of the femur is then rounded off, so as to form with the upper portion a species of artificial ball-and-socket joint, which is designed to take the place of the anchylosed hip-joint.

Scarenzio's Treatment. The treatment of syphilis by subcutaneous injections of calomel.

Scarpa's Method. Ligation of the femoral artery at the middle of Scarpa's triangle.

Scheiner's Test. A test for determining whether an eye is emmetropic, by looking at a point of light through two minute apertures placed close together.

Schröder's Operation. 1. Myomectomy (see vol. iii p. 811).

2. Same as the Sauter operation.

Schueller's Operation. An operation for the cure of entropion, by making two elliptical skin incisions united at their ends, and then suturing the distal margins of the incisions together *over* the included portion of attached skin.

Schultz's Method. A method of resuscitating the newborn. The child is held by the shoulders, the thumbs resting upon the thorax, the child's head toward the operator, and its anterior surface to the front; it is then swung upward, so that its feet perform a revolution, and lie between the head and the operator's body, the trunk being then in a state of forced flexion. The original position is then resumed by a reverse motion, and the repetition of these movements constitutes the method.

Scoutetten's Method. The oval method of amputating (see vol. i., p. 149).

Sedillot's Method. The same as Mackenzie's.

Sexton's Operation. An operation for the radical cure of persistent otorrhœa depending on inflammation of the tympanum, antrum, ossicles, and often of the mastoid cellules, in cases where the drumhead has been almost or entirely destroyed, and where the incus is usually separated from the stapes. The operation consists in the excision of any remaining vestiges of the membrana flaccida and membrana vibrans; of the malleus and incus, if present, and of granulation and carious tissues, with the object of ensuring drainage and treating the middle-ear tract, so that healing by cicatrization throughout may take place.

Sigault's Operation. Pubic symphysiotomy.

Signorini's Method. A method of operating for the cure of hernia, similar to Gerdy's, except that a female catheter takes the place of the finger, and three pins are used instead of the sutures.

Simon's Method. The exploration of the rectum and adjacent parts by the introduction of the hand, or the hand and arm, of the operator. The operation should not be undertaken, under ordinary circumstances, by one whose hand measures, when made into a cone, more than seven and one-half or eight inches in circumference. The rectum, the sigmoid flexure, and even in suitable subjects the descending colon, can be thus explored.

Simon's Operation. 1. An operation for closure of complete laceration of the perineum. The edges being freshened, sutures are first passed so as to include only, but all, the denuded *rectal* mucous membrane. Each suture commences and ends in the rectum, and is tied in the rectum as soon as passed. After the rent in the rectum is closed, the rest of the lacerated structures are brought together in the usual manner. The rectal sutures are to be cut short, and allowed to work out at will.

2. Posterior colporrhaphy.

Simon's Position. The exaggerated lithotomy position. Used by Simon in operations about the vagina.

Simpson's Method. The method of treating placenta prævia by the complete separation of the placenta.

Simpson's Operation. Bilateral division (discission) of the cervix uteri. This operation is done with a metrotome, which divides both the internal and external os and makes the canal of the same width throughout. It is applicable only to cases in which the intra-vaginal portion of the cervix is normally developed, in which the anterior and posterior segments of the cervix are symmetrical, with the os pointing usually toward the posterior wall of the vagina. It is performed only for the relief of dysmenorrhœa and sterility due to constriction of the canal.

Sims's Operation. Antero-posterior division of the cervix uteri, in cases where the intra-vaginal portion of the cervix is unequally or abnormally shaped, the posterior segment being longer than the anterior, and the body of the uterus anteflexed.

Sims's Position. The latero-abdominal position. The patient lies on her side (left, usually), on a perfectly flat, hard table, the head on a low pillow, the lower shoulder and that half of the thorax touching the table, the other

shoulder but slightly raised from it, the lower arm thrown out behind and hanging over the edge of the table, the lower hip touching the lower edge of the table, the upper hip somewhat back in correspondence with the upper shoulder, the thighs and knees flexed at right angles, the upper knee slightly overlapping the lower, and the feet close together, projecting over the corner of the table and supported by the back of a chair or other article of furniture.

Skeer's Symptom. A symptom of tubercular meningitis, considered pathognomonic by Dr. Skeer. It is said to be present during the first or second stage of the disease, and consists in a small circle which forms in the iris, near to and completely surrounding the pupil. When beginning, it is indistinct and resembles a wreath of thin white clouds, the edge of which extends at first to the pupillary margin. In from twelve to thirty-six hours the whole margin of the iris will be involved, becoming of whitish or yellowish-brown color, and appearing irregular, thickened, and somewhat granular. These changes, which commence in both eyes simultaneously, are more apparent in irides of brown color. This cloud-like appearance is in some cases very evanescent, hence the necessity of examining the iris at every visit. It may appear in the evening, and by the following morning have given place to the yellow-brown rings caused by the subsequent change in the tissues. These later rings are permanent and grow narrower and larger with the progressive dilatation of the pupils as the disease advances. In primary tubercular meningitis, the circles appear early, before or during the decline of the fever which characterizes the first stage of the disease. In cases where a simple inflammation has called into activity a latent tubercular tendency they appear in the second stage of the disease. Care should be taken to know that these circles have appeared since the illness commenced, otherwise they might be mistaken for the light-colored circles which, especially in scrofulous children, sometimes exist *on* the free border of the iris.

Skene's Tubes. Two very small tubes, running parallel with the urethra in woman, connected with delicate glands and opening on the margin of the meatus. They probably represent the vesiculæ seminales and their ducts in the male.

Skoda's Sign. A peculiar tubular resonance (the vesiculo-tympanitic resonance of Flint), heard on percussion when a pleural effusion extends up to the fourth rib or beyond it.

Smith's Method. A method of amputating at the knee-joint, in which lateral tegumental flaps are made by two incisions which commence one inch below the tubercle of the tibia and, diverging over the sides of the leg, join each other posterior to the articulation, the patella being retained.

Smith's (Tyler) Method. Reduction of uterine inversion by distending the vagina with an inflated rubber bag, after having applied massage to the uterus twice daily for ten days.

Snellen's Operation. A modification of Streatfeild's operation for entropion.

Snellen's Test Types. A series of test types for measuring the acuity of vision and reading, based upon the fact that the smallest visual angle which admits of distinct vision is one of five minutes.

Socin's Method. The removal of tumors of the thyroid gland by cutting through the normal gland-structure and then enucleating the neoplasm. The occurrence of the cachexia strumapriva is thus avoided.

Sotteau's Method. A method of operating for the cure of hernia (see vol. iii., p. 637).

Spanton's Operation. An operation for the cure of hernia, by uniting the rings by a corkscrew-like instrument (see vol. iii., p. 641).

Spence's Method. A method of amputating at the shoulder-joint very similar to Larrey's (see vol. i., p. 163).

Squire's Method. A method of curing "port-wine marks" by multiple parallel incisions.

St. Anthony's Dance. Chorea.

St. Anthony's Fire. Erysipelas.

St. Guy's Dance. Chorea.

St. John's Dance. Chorea.

St. Modestus's Dance Chorea.

St. With's Dance. Chorea.

St. Vitus's Dance. Chorea.

Steele's Operation. A modification of Blandin's, by which, by means of a punch bearing on one of its blades a series of diverging knives, stellate incisions are made in the nasal septum.

Stilling's Operation. Internal incision in stricture of the nasal duct.

Stokes's Disease. Exophthalmic goitre.

Stokes's Operation. An operation for the cure of flat-foot, by removing a wedge-shaped piece of bone from the head and neck of the astragalus.

Stoltz's Operation. An operation for cystocele, consisting in denuding a circular portion of the anterior vaginal wall and running a thread around this, about half an inch from its edge, after the manner of the puckering string of a purse or tobacco-pouch. This thread is then drawn tight and tied. This operation can then be followed, if necessary, by the usual colpo-perineorrhaphy.

Streatfeild's Incision. An incision, in cataract extraction, made with a Sichel's knife, without counter-puncture, the wound being enlarged by a sawing movement.

Streatfeild's Operation. 1. An operation for the cure of entropion, by removing a strip of tissue, including a "groove" of the tarsus, and attaching the lower edge of the incision to the upper border of the tarsal groove.

2. The same as Passavant's, except that a cutting-hook is used instead of forceps.

3. An operation for slitting the canaliculus when there is obliteration of the punctum: the canaliculus above (or below) is laid open and a fine director is passed through this into the opposite canaliculus, and through the punctum if possible; it can then be laid open.

Streatfeild-Snellen Operation. An operation like first above, except that the "groove" is made higher up.

Syme's Amputation. An amputation at the ankle-joint, in which the fleshy cushion of the heel, dissected from the calcaneum, constitutes the flap to cover the ends of the tibia and fibula, the malleoli and articular cartilage having been previously sawn off (see vol. i., p. 166).

Syme's Method. The making of oval tegumentary flaps in amputating.

Szokalski's Operation. Ligation of pterygium, by means of a thread armed with two needles, so that the growth is strangulated at each end, and *en masse* between.

Szymanowski's Operation. An operation for the cure of urethral fistula. A straight incision is made, beginning a short distance in front of the opening and ending a short distance behind it. The skin on one side of the fistula is then undermined with the knife, and made freely movable. A half-oval flap of skin on the other side of the fistula is then cut, dissected up, except at the edge of the fistula, and its epidermis removed, except from that portion which is to cover the opening. The dissected flap is then inverted, turning on its attached edge as on a hinge, pushed under the previously detached skin on the opposite side, where it is held in place by properly adjusted sutures, and the movable skin drawn over it and sutured. The fistula is thus covered by two thicknesses of skin. The urine must be drawn by catheter for several days.

Tagliacozzi's Operation. The operation for making a new nose by taking a flap from the upper arm, the arm being then strapped to the head until the flap unites.

Tait's Law. "In every case of disease of the abdomen or pelvis *in which the health is destroyed or life threatened, and in which the condition is not evidently due to malignant disease*, an exploration of the cavity by laparotomy should be made."

Tait's Operation. "Removal of the uterine appendages for physical disease other than cystoma: as the removal of the ovaries and tubes for uterine myoma; the removal of a tube for pyosalpinx, or other disease; or the removal of both ovaries and tubes for chronic inflammatory disease and adhesions."

Tate's Method. Similar to Watts's, except that one finger is also passed into the bladder to act in conjunction with those in the rectum.

Taylor's Operation. An operation for cataract, in which the incision is made with a broad needle, the capsule is then lacerated, and an artificial pupil made through which the lens is extracted.

Taylor's Stitch. The cobbler-stitch, used to bring together the flaps after amputation of the cervix uteri.

Teale's Method. This differs from Ravaton's chiefly in making the flaps of unequal length. The long flap, the first to be cut, equals in length one-half the circumference of the limb at the point of amputation, and the short flap is one-fourth the length of the long one (see vol. i., p. 151).

Teale's Operation. 1. The dissection from the globe of the adherent lid, in symblepharon, and covering the globe with healthy conjunctiva.

2. Removal of soft cataract by suction (see vol. i., p. 797).

Thiersch's Fluid. An antiseptic solution: Salicylic acid, one grain; boric acid, six grains; water, one ounce.

Thiersch's Method. A method of operating for the cure of epispadias, very similar to Anger's method for hypospadias.

Thomas's Operation. Laparo-elytrotomy.

Thomsen's Disease. Myotonia congenita (Strumpell). A disease involving the voluntary muscles, congenital, or, at least, appearing very early in life, and usually affecting several members of the same family. It is characterized by a peculiar stiffness and tension of the muscles on attempting to perform any voluntary movement, particularly after the subject has been at rest for some time. The entire body may thus become temporarily stiff. Rapidity of muscular action is impossible, as at each attempt the muscles involved pass into a state of tonic, long-continued, painless contraction, which only gradually subsides; but if exercise be continued, the muscles, after getting warmed up, lose nearly all their rigidity. The subject is otherwise well. In muscles excised during life there is found enormous hypertrophy of all the fibres, increase of the nuclei, indistinctness and vacuolation of the substance, and thickening of the connective-interstitial tissue. No opportunity to examine the nervous system has yet occurred, but Erb thinks the disease is a pure myopathy. The disease is probably incurable, but it does not seem to lessen the duration of life.

Tornwaldt's Disease. Hypersecretion of Luschka's gland.

Tourette's (Gilles de la) Disease. An affection characterized by incoördinate movements, and by echolalia and copsolalia (automatic echo-speech and obscene speech).

Traube's Plugs, The same as Dittrich's Plugs.

Traube's Semilunar Space. A space on the left side of the chest, where there normally is found a vesiculo-tympanitic sound, due to air in the stomach. It is bounded below by the margin of the thorax, and above by a curved line, with its concavity downward, which begins below the fifth or sixth costal cartilage and extends backward along the margin of the chest as far as the top of the ninth or tenth rib. Its greatest breadth is from four to four and a half inches. The tympanitic sound disappears from this space when the diaphragm is depressed by a pleural effusion into the left side.

Travers's Operation. An operation for cataract, in which the capsule is divided and the lens displaced into the anterior chamber; it is then removed through a small corneal incision.

Trousseau's Sign. A diagnostic sign of tetany, consisting in exciting a paroxysm artificially by pressing upon the larger arteries or nerves of the arm, particularly the median nerve and the brachial artery.

Trousseau's Spots. Red spots which may appear on the skin after it has been mechanically irritated. Trousseau laid weight upon them as diagnostic of meningitis (*taches cerebrales*), but they are due to increased reflex action and may be seen in all sorts of acute diseases.

Tufnell's Treatment. A method of treating [illegible] consisting of *absolute rest* for weeks or even months, with a diet restricted as follows: For breakfast, two ounces of bread-and-butter, and two ounces of new milk; for dinner, two or three ounces of bread, two or three ounces of meat, and three or four ounces of milk or claret; for supper, same as for breakfast.

Tyndall's Process. Sterilization by discontinuous heating (see vol. iv., p. 771).

Valentine's Method. Reduction of uterine inversion by seizing the uterus by the fingers and thumb of one hand and exerting pressure, while counter-pressure is made with the other hand at the hypogastrium.

Valette's Method. A method of operating for the cure of hernia (see vol. iii., p. 638).

Valsalva's Method. Auto-inflation of the middle ear. The subject closes both of the nostrils by grasping the nose with the thumb and forefinger of one hand, shuts his mouth firmly, and then makes a strong expiratory effort (see vol. ii., p. 577).

Valsalva's Treatment. The treatment of aneurism by blood-lettings and starvation (see vol. i., p. 225).

Van Best's Operation. Subcutaneous suturing of the rings for the cure of hernia (see vol. iii., p. 640).

Vater's Diverticulum, or Ampulla. A pouch formed by the entrance of the pancreatic duct into the bile-duct. A calculus lodged at this point sometimes leads to fatal results, owing, it is supposed, to the effect on the heart of irritation reflected from the large number of ganglia contained in this diverticulum.

Veit's Operation. Same as Porro-Veit Operation.

Vermale's Method. 1. The reverse of Langenbeck's.

2. Amputation of the thigh by lateral musculo-tegumentary flaps.

Verneuil's Operation. The same as Lente's operation, except that his incision is posterior only.

Videl's Operation. An operation for the cure of varicocele.

Voltolini's Disease. An acute disease of childhood, beginning with cerebral symptoms and leaving permanent deafness. Supposed by Voltolini to be a primary inflammation of the labyrinth, but it is more probable that the primary disease is a meningitis which secondarily affects the internal ear.

Wardrop's Operation. The same as Brasdor's, except that some branches are not ligated, so that the current is not entirely arrested (see vol. i., p. 212).

Warlomont's Incision. A modification of the Graefe incision in cataract extraction.

Warlomont's Operation. An operation for trichiasis, in which the portion of the lid in which the cilia are emplanted is detached, shifted upward, and fixed upon the tarsus.

Watts's Method. Reduction of uterine inversion as by Courty's method, except that the fingers passed into the rectum are used to dilate the inverted cervix.

Weber's Method. Arresting arterial hæmorrhage by turning the vessel inside out, by means of an instrument called an arterio-verter.

Weber's Operation. Cataract extraction by means of a lance-shaped knife, and with a peculiar method of lacerating the capsule: no iridectomy.

Wecker's Operation. See De Wecker.

Wedl's Solution. A stain for micro-organisms (see vol. iv., p. 763).

Weigert's Solution. A stain for micro-organisms (see vol. iv., p. 763).

Weigert-Ehrlich's Solution. A stain for micro-organisms (see vol. iv., p. 763).

Werlhof's Disease. Purpura hæmorrhagica.

Westphal's Symptom. The absence of the knee-jerk.

Westphal-Erb Symptom. Same as Westphal's symptom.

Wharton's Method. A modification of Teale's, consisting in making only a single flap, and sawing off the bone at what would be the lower end of Teale's short flap.

White's Method. 1. A method of operating for the cure of hernia (see vol. iii., p. 639).

2. Reduction of uterine inversion by pressure upon the fundus by means of a cup having at its base a short staff terminating in a steel spiral spring, which rests against the operator, counter-pressure being made above.

Wicherkiewicz's Operation. The removal by means of a small, sharp spoon, of the diseased tissue in stubborn scleritis.

Wilde's Incision. An operation for securing local depletion in commencing inflammation of the mastoid. The skin and subjacent tissues, inclusive of the periosteum, are divided by an incision extending from the base of the mastoid process—on a level with the upper margin of the auditory meatus—very nearly to its apex (see vol. iv., p. 669).

Wilde's Operation. An operation for staphyloma, very similar to Critchett's.

William's Tracheal Tone. The peculiar resonance sometimes found in the second intercostal space in cases of very large pleural effusions. It is a dull tympanitic resonance, which becomes higher on opening the mouth, and arises from the vibrations of air in a large bronchus surrounded by compressed lung.

Willis's Disease. Diabetes.

Winckel's Disease. A form of acute fatty degeneration of the new-born, characterized by cyanosis, jaundice, and hæmoglobinuria, death occurring usually in about two days.

Wladimiroff's Operation. The same as Mikulicz's operation.

Wladimiroff-Mikulicz's Operation. The same as Mikulicz's operation.

Wolfe's Operation. 1. The operation of transplanting skin or conjunctiva *en masse*, in the treatment of deformities of the eyelids, etc.

2. Corneal transplantation.

Wölfler's Operation. The establishment of an opening between the stomach and the upper portion of the small intestine, in cases of malignant stenosis of the pylorus.

Wood's Method. A method of operating for the cure of hernia (see vol. iii., p. 639).

Wood's Operation. An operation for the cure of exstrophy of the bladder.

Wright's Method. A method of extracting cataract. The incision is made with a Beer's knife, and is entirely within the cornea. The puncture and counter-puncture are made near the sclero-corneal border, about one-third the way down from the upper border of the cornea, and the knife cuts upward and outward at an angle of forty-five degrees with the plane of the iris. The upper border of the incision is then depressed with the finger, and the lens removed; without, if possible, either rupturing its capsule or performing iridectomy, although either or both of these operations may be performed if necessary.

Wutzer's Method. A method of operating for the cure of hernia (see vol. iii., p. 637).

Young's Rule. A rule for dosage of children: Give so much of the adult dose as is represented by a fraction formed by dividing the age of the child by the age plus twelve; thus for six years, the fraction will be $\frac{6}{6+12} = \frac{6}{18} = \frac{1}{3}$.

Zenker's Degeneration. A peculiar change in the muscles, occurring occasionally in severe attacks of typhoid fever, or other febrile diseases. *J. F. Baldwin.*

[1] See How to Work with the Microtome. Bausch & Lomb, Rochester, N. Y., 1886.

NOSE: ABSCESS OF THE SEPTUM. Abscess of the nasal cavity rarely occurs excepting in the septum, and even here it is seldom met with. It is generally due to traumatism, but may be caused by extension of inflammation from a furuncle, or, more rarely, may occur as the result of irritation from chronic or purulent coryza. It is sometimes symptomatic of general affections, such as small-pox, scarlet fever, typhoid fever, and phlegmonous erysipelas. In rare instances, one of which has been reported by the writer, it has been idiopathic.

The symptoms of acute abscess vary in intensity with the severity of the causes by which the abscess is produced, and with the extent of the abscess itself. There is more or less febrile movement, headache, throbbing, and lancinating pain which is increased on pressure, or upon blowing the nose. The inflammation at the same time extends to the face, giving it an œdematous or erysipelatous appearance. The nasal passages are obstructed, with the result of shutting off nasal respiration, and causing loss of the olfactory sense and change in the quality of the voice. Secretion is diminished until opening of the abscess takes place when it becomes purulent or sanious. Examination of the nares reveals a swelling, usually symmetrical, on both sides of the septum, and generally well down toward its anterior and inferior part. The tumefaction, if at all pronounced, effectually cuts off further examination of the nasal cavity by anterior rhinoscopy. The mucous membrane is red and sodden, and fluctuation may often be detected. The septum is likely to suffer perforation from destruction of more or less of the cartilaginous part, so that the abscess-cavities coalesce, and pressure upon one produces fluctuation in the other.

Cold abscess of the septum must be extremely rare, although such cases have been reported. Their onset is gradual, and unmarked by the acute symptoms described above. The course of acute septal abscess may be rapid, and early diagnosis is, therefore, of great importance, since, if treatment be delayed, extensive destruction of the septum and marked external deformity of the nose may result. In the case of an acute abscess the diagnosis may be made with comparative ease. Chronic abscess may be identified by the presence of fluctuation, particularly if the septum has become perforated, and, if necessary, aspiration may be resorted to as an aid to the diagnosis.

Abscess of the septum may be complicated with facial erysipelas, destruction, more or less extensive, of the bones and cartilages of the septum, and even of the nose itself, and possibly by meningitis and phlebitis. Of the sequels most likely to follow, loss of the septum and consequent deformity of the nose will take precedence.

Treatment should be both general and local. The former will be suggested by the necessities of the case in hand. The local condition should be treated with great promptness and thoroughness. If an abscess is impending, efforts should be made to dissipate it, by means of inhalations of steam. As soon as the presence of pus can be detected free incision should at once be made into both sides of the septum and at a point from which the cavity can be well drained. Should the septum be perforated, drainage may be effected by means of several strands of lamp-wick, or other suitable material passed through the incisions. Meanwhile, absolute cleanliness of the nasal passages by means of some mild antiseptic solution should be maintained. *D. Bryson Delavan.*

NOSE: AFFECTIONS OF THE NASAL PHARYNX. Anæmia.—The pharyngeal membrane shares in the general pallor of the mucous membranes of the body in loss of blood from any cause, or in derangements of its circulation, and in all diseases in which the number of its red globules is diminished. It occurs in hysteria, and is characteristic not only of the incipient stage of tuberculosis but also of the later throat history of that disease. It is met with in atrophic conditions of the mucous membrane, and may occur suddenly from emotional excitement or from depression of the nervous apparatus in syncope or shock. Wendt[1] observes that the approach of fainting, during the examination of the pharynx, may be frequently recognized by the coldness and pallor of the mucous membrane.

Inspection reveals the dark-purplish or wine-colored vessels thrown on the yellowish or whitish background of the anæmic membrane. The follicles often appear as small, transparent, shining nodules, scattered in profusion over the bloodless membrane. In some diseases, as in hysteria and tuberculosis, the reflex excitability of the pharynx is very pronounced, while in others, as in glosso-labio-laryngeal paralysis, it is diminished or almost destroyed.

Hyperæmia and Hæmorrhage.—Hyperæmia and hæmorrhage of the nasal pharynx are of frequent occur-

rence as the result of direct injury, either chemical or mechanical; as sequels of a host of blood diseases, including purpura, scurvy, hæmatophilia, the exanthemata, erysipelas, typhoid fever, septicæmia, diphtheria, etc.; in poisoning from various drugs, as iodine, mercury, phosphorus, etc.; they may be due to mechanical obstruction to the venous circulation in the neck, thorax, or abdomen, or occur as complications of organic disease of the kidney, heart, lungs, etc. They may also follow overfilling of the vessels from increased arterial tension, or proceed from various constitutional affections, such as syphilis and tuberculosis, from ulceration of various kinds, morbid growths and obstruction in the nasal passage. An occasional cause of naso-pharyngeal hæmorrhage is encountered in a varicose condition of the pharyngeal veins.

The bleeding comes generally from the rupture of superficial vessels; but in affections of the blood it is often parenchymatous. The amount may be very slight and the rupture be represented by a small extravasation or ecchymosis, or extensive hæmorrhagic infiltration of the tissues may occur, constituting a veritable blood tumor or hæmatoma.

Acute Inflammation.—Acute inflammation of the retro-nasal space may occur as a primary affection from operative interference in that region, or from the application of chemical irritants to its mucous membranes, and possibly from the inhalation of irritating vapors and dust through the nostrils. It may also occur as a symptom of morbid growths and ulceration of the upper pharynx and pharyngeal tonsil. Localized inflammation of this region is not uncommon after diphtheria and scarlet fever and other blood diseases. It is generally, however, due to an extension of inflammation from the nose or lower pharynx, or occurs as a part of general diffuse inflammation of the upper respiratory tract (see also article on Catarrhal Inflammation, vol. iv., p. 400).

The rhinoscopic appearances are those of intense hyperæmia, either diffused over the whole space or localized in individual parts, with swelling of the mucous membrane. The mouths of the Eustachian tubes are swollen, and give to the eye the appearance of an enlarged inflamed cervix uteri. Their calibre is diminished by the swelling, and thick shreds of mucus hang from their orifices. Especially noticeable is the increase in volume of the pharyngeal tonsil, which presents a great variety of appearances, and is occasionally so much enlarged as to exert considerable pressure on the Eustachian tubes and produce obstruction of the posterior nares. The upper portion of the posterior edge of the septum is generally swollen and presents a more or less heart-shaped appearance; its vessels are enlarged and tortuous.

In some blood diseases, as in small-pox, pyæmia, scurvy, purpura, etc., hæmorrhagic, and even purulent infiltration of the mucous and submucous tissues takes place; this may be quite extensive or may occur as minute extravasations or capillary apoplexies.

Sometimes a granular condition of the mucous membrane is a conspicuous feature, and is due to participation of the follicles in the inflammatory process. I have never observed ulceration in this cavity from an acute simple inflammation.

Secretion is always profuse; at first it is mucous, glairy, tenacious, and sometimes streaked with blood; later it becomes muco-purulent or purulent, accumulates rapidly, and fills the cavity with a yellowish discharge. This is partially removed by inspiration through the nostrils and hawking; or it gravitates into the lower pharynx and is expectorated. Its voluntary removal here is, however, more difficult than in the lower pharynx, and hence inspection always reveals more or less secretion adhering to the vault and pharyngeal walls.

The accumulation of secretion and the swelling of the mucous membrane occasionally produce obstruction of the posterior nares, with its consequences (see article on Chronic Nasal Catarrh, in the Appendix. If the secretion be allowed to remain in the retro-nasal cavity, headache, general malaise, slight febrile movement, and symptoms referable to obstruction of the Eustachian tubes develop. During convalescence from diphtheria, scarlet fever, and similar affections, I have observed considerable elevation of temperature produced by the retention and decomposition of the secretion in the retro-nasal space.

The inflammatory process not infrequently extends into the nose and lower pharynx, or through the Eustachian tubes to the middle ear, and its symptoms are lost or become inconspicuous by comparison with those of the disease to which it leads.

Pathology.—The affection is a simple inflammation of the retro-nasal space, and presents no characteristics which differentiate it from the ordinary forms of catarrhal inflammation. Occasionally the inflammatory exudation assumes a membranous form, especially in congenital syphilis.

Prognosis, Course, and Sequels.—Recovery here is, as a rule, less rapid than in acute inflammation of the lower pharynx, and the tendency to result in chronic inflammation is greater. This is probably due to the fact that, as the symptoms of ordinary subacute cases are such as give rise to comparatively slight discomfort, the proper treatment of the affection is almost invariably neglected. The gravitation of the secretion into the lower pharynx leads the patient, moreover, to refer his trouble to that region, a diagnosis which is often accepted unreservedly by his medical attendant. The inflammation of the retro-nasal space which occurs in children, as, for example, after the exanthemata, is, as a rule, neglected, and the foundation thereby laid for chronic catarrhal disease of the nasal passages and middle ear in after-life.

Properly treated, a mild, uncomplicated, acute inflammation of the nasal pharynx will get well in a few days, but in cases of more than ordinary severity recovery may be delayed for several weeks.

Treatment should be conducted on the general principles which will be considered in the article on Chronic Nasal Catarrh, in the Appendix. The retro-nasal space should be kept as free as possible from secretion, and mild astringent and alterative remedies applied in the form of spray. Soothing inhalations through the nose may also be employed with advantage, and, as resolution occurs, may be followed by those of a more stimulating character.

Chronic Catarrhal Inflammation.—Chronic retro-nasal catarrh may be primary or secondary to inflammatory conditions of neighboring organs, especially of the nasal fossæ. As an independent primary affection it not infrequently occurs as the result of a subacute attack or repeated acute attacks, the tendency being somewhat greater here than in the lower pharynx, as above remarked, to pass into the chronic form of inflammation.

Chronic retro-nasal catarrh is due to the operation of causes similar to those considered in the article on Chronic Nasal Catarrh, in the Appendix. What influence, if any, the conformation of the retro-nasal space, as to breadth and depth, exerts as a predisposing influence, has not as yet been satisfactorily determined. Naso-pharyngeal inflammation prevails in every country in which the intense, frequent, and rapid changes of atmospheric conditions occur which have been discussed under the head of Etiology of Catarrhal Affections in General, vol. iv., p. 400.

Anatomical Changes.—Changes in color. The mucous membrane may be uniformly hyperæmic, presenting a diffuse injection varying from a yellowish-red to a deep-bluish hue, or the hyperæmia may be more pronounced in certain situations than in others. Small extravasations of blood are common, and result from the rupture of capillaries and enlarged veins. These appear generally in the form of ecchymoses; but in some cases, as in the retro-nasal catarrh of certain blood diseases, the hæmorrhagic infiltration may be considerable; or true bloody tumors may be formed. Anæmia, or at least a less pronounced coloration of the mucous membrane, is common in those diseases characterized by impoverishment of the blood, and especially is this true of the form which accompanies pulmonary tuberculosis. In these conditions

the enlargement and overfilling of the venous plexuses is most conspicuous. Later on, when atrophy of the membrane supervenes, the prominence of the veins becomes more pronounced. A varicose condition of the vessels on the posterior edge of the septum is not infrequently encountered, and those surrounding the orifices of the Eustachian tubes are often dilated and tortuous, forming a more or less vascular, wine-colored net work which extends into the nasal fossæ and ramifies over the inferior and middle turbinated bodies. Occasionally the vessels show signs of atheromatous degeneration.

There is almost always more or less swelling of the mucous membrane of the parts. This is most marked on the pharyngeal tonsil and the septum. The swelling of the former is at first inconsiderable, but later in the disease hypertrophy of its tissues takes place and it appears as a well-defined, irregularly lobulated mass, or a uniformly smooth, sessile tumor. This hypertrophic condition of the pharyngeal tonsil is at times so excessive as to materially diminish the lumen of the Eustachian tubes and posterior nasal orifices. Occasionally it presents a nodular appearance or is covered by grooves or furrows with corresponding elevations of tissue. In other cases the hypertrophy of the glandular tissue of the vault exhibits itself as a mass of adenoid or polypoid vegetations, and especially is this true in children, as the result of the naso-pharyngeal complications of acute febrile disease, and notably after diphtheria and scarlet fever.

The orifices of the Eustachian tubes are generally enlarged, tumefied, and reddened; they are dilated and patulous. This gives the tube the appearance of an enlarged cervix uteri in a state of chronic hyperplastic inflammation. Occasionally a granular condition is observed, due to swelling of the muciparous glands of the tube (tubal tonsil of Gerlach). The tubes themselves are sometimes occluded, or their orifices displaced by pressure of the enlarged pharyngeal tonsil, and, in rare instances, of the hypertrophied turbinated bodies.

In long-standing cases there is almost always a corresponding hypertrophy of the posterior half of the septum, which causes a bulging on either side of the median line, which, with the central depression, presents sometimes a heart-shaped appearance.

In cases of long duration, too, true papillary growths develop, which should not be confounded with the so-called adenoid vegetations of this region. I have met with these papillomatous formations more frequently on the posterior part of the palate and septum; but they may occur also in other parts of the cavity.

In other instances, simple thickening of the epithelium occurs, which gives the membrane an irregular, nodular appearance. The changes in the granular or glandular disease of the naso-pharyngeal space will be given in the article on Chronic Nasal Catarrh, in the Appendix.

We cannot confirm the observations of certain German writers, that well-marked ulceration occurs in this locality as the result of simple inflammation.

Erosions and small follicular ulcerations occur; but the former are usually the result of accident (*e.g.*, from separations of crusts, etc.) and the latter are of minor clinical importance.

On the other hand, cystic formations are frequently met with, especially in the substance of the pharyngeal tonsil. They vary greatly in size, from a pin's head to that of a hazel-nut, and are filled with an opaque, colloid substance containing cholesterine, fatty débris, and sometimes calcareous matter. These cysts may be formed in the usual way, by closure of the gland-ducts, or, as Wendt[2] has pointed out, may originate from newly formed depressions of the mucous membrane, due to hypertrophic enlargement in ridges, or to swelling of the membrane and the consequent temporary interference with their communication with the external surface.

The mucous glands and lacunæ are generally enlarged and surcharged with secretion, and hæmorrhages occasionally take place into the latter.

The appearance of the posterior nares will be given in the article referred to above.

Changes in secretion. The changes in quantity and quality of the naso pharyngeal secretion are the most conspicuous clinical features of the disease. The pharyngeal tonsil is generally covered with a thick, tenacious, yellowish-white or greenish-yellow secretion, which is often further discolored by the admixture of extraneous particles of matter from the atmosphere, the rupture of cysts, and small hæmorrhages from the mucous membrane. The exudation soon loses its aqueous constituents by evaporation, and tough masses are formed, which cling with great tenacity to the walls of the pharynx, become impacted in the fossæ of Rosenmüller, in the posterior nares, or, finally, hang from the orifices of the Eustachian tubes. When they are not removed they become so dense in consistence as to resemble a leathery or membranous formation, and come away as casts of various portions of the cavity. The tenacity with which the dried secretion adheres to the membrane is sometimes so great as to require instrumental aid for its removal.

Symptoms.—The most prominent symptom of retro-nasal catarrh is the accumulation of the secretion in the back of the nose and upper portion of the pharynx, from which it is sometimes poured out as from some inexhaustible reservoir. This is removed by forcible inspiration through the nose, followed by hawking, or by the forcible contraction of the pharyngeal and palatal muscles in the acts of deglutition and sneezing. In the latter case it is expelled through the nasal passages or mouth, according to the completeness with which it is separated from the pharyngeal walls. It may also be loosened and discharged by various methods of expiration or by the rapid alternation of inspiration and expiration through the nose. Occasionally the tongue of the patient becomes the medium of its removal. A number of cases illustrating this abnormal motility of the tongue have been reported. One of my patients, a physician of Baltimore, and suffering from posterior hypertrophic catarrh, made a complete and accurate diagnosis of the condition of his upper pharynx and posterior nares by means of his tongue, with which organ he was also accustomed to remove the secretion from the retro-nasal space.

When the tongue is depressed a more or less tenacious, thick, ropy mass of secretion is seen hanging down from behind the palate, or appears in a few seconds on the contraction of the pharyngeal and palatal muscles. The presence of this post-nasal plug is characteristic of the disease. Occasionally a frothy liquid discharge precedes the descent of the plug. Another characteristic to which we would also call attention is the peculiar odor of the post-nasal pharyngeal secretion, which is of considerable diagnostic value. It is altogether peculiar and sickening, and when once appreciated by the sense of smell is never forgotten.

The voluntary removal of secretion from the retro-nasal space is, for obvious anatomical and physiological reasons, not accomplished with the same facility as it is from the lower pharynx. Hence accumulation and inspissation are more likely to occur in the former locality. It is probable, too, that the toughened secretion gains in hardness and tenacity by the admixture of colloid material from the cystic formations which constitute such a striking anatomical feature of the disease.

A certain amount of dulness of the head accompanies the retention of these masses, and the patient becomes irritable and incapacitated for vigorous mental labor. Much of the exudation gravitates into the lower pharynx and is swallowed, producing irritation of the stomach, with a host of symptoms referable to disordered nutrition; or the masses become loosened during sleep, and, falling within the laryngeal vestibule, excite choking sensations or veritable spasm of the glottis. This latter may be produced also by reflex action from the irritation induced by the presence of the inspissated mucus in the naso-pharyngeal space. Various other reflex phenomena are also observed, which will be discussed farther on, under the head of Neuroses.

In some persons, especially those predisposed to hyperæmic conditions of the air-passages in general, quite extensive hæmorrhages occur upon exposure to appar-

ently trivial causes. In this way several ounces, or more, of blood, may be lost. The blood is swallowed and vomited, or it may excite cough and be expectorated, and create in the mind of the patient and his attendant a belief in its pulmonary origin. This post-nasal hæmorrhage usually takes place suddenly and during attempts to forcibly clear the nose.

The symptoms of retro-nasal catarrh are always aggravated in the morning upon rising, but are diminished in severity after the moistening of the throat and the deglutitory movements which take place during the morning meal. They are also increased by excessive smoking, drinking, and other unnatural indulgences. The breath is more offensive after talking or confinement in close or crowded rooms.

Complications.—Retro-nasal inflammation derives much of its importance from its intimate relation to catarrhal affections of the Eustachian tubes and middle ear. Besides these common complications, it may lead to insufficiency of the palatal muscles, various laryngeal, nasal, œsophageal and gastric disturbances, and to a host of neurotic phenomena (see farther on, in article on Neuroses).

Diagnosis.—The diagnostic characteristics of the disease have been given in connection with its clinical and pathological history. When rhinoscopic examination is possible there will be no difficulty in recognizing the affection. If this be not practicable, as, for example, in young children, the introduction of the index-finger behind the velum will determine the presence or absence of adenoid growths, polypi, and hypertrophic conditions of the posterior nares with which the disease may otherwise be confounded.

Prognosis.—The prognosis in catarrhal affections of the nose and nasal pharynx will be more fully discussed in the article on Chronic Nasal Catarrh, in the Appendix. Suffice it here to say, that in simple, uncomplicated inflammation of the retro-nasal cavity that has not lasted for over a year, the prognosis is good. It is also favorable when the morbid process proceeds from neoplastic changes in the pharyngeal tonsil, and when it depends upon some removable nasal affection. As the local expression of a constitutional condition, as, for example, gout, rheumatism, chronic alcoholism, etc., it is a more difficult affection to deal with. Whether simple, complicated, or symptomatic of diathetic conditions, chronic nasal pharyngitis is one of the most difficult of all inflammatory troubles to cope with. The more experience the physician has in the management of this affection the less inclined will he be to paint its prognosis in roseate colors. Given an inflammation of several years' duration, more or less clearly confined to the naso-pharyngeal space, without obstructive lesions of the nose or nasal pharynx removable by surgical means, in an individual subjected to improper hygienic conditions and surrounded by the constant changes of temperature of a capricious climate, the chances of complete recovery are decidedly problematical and unfavorable. Marked relief may be given, and the affection be even temporarily dissipated, but sooner or later the inflammatory process reasserts itself, and perfect cure is only secured in an equable climate and under favorable hygienic conditions. There are exceptional cases in which this rule does not hold good, but they are, unfortunately, in a deplorable minority.

It may be said, in general, that the disease is more amenable to treatment in early life, less so in manhood and after forty, while later in life it furnishes the most striking confirmation of the Hippocratic dictum that, "Catarrhs in the aged are not concocted."

Treatment.—As I have stated elsewhere,[3] I regard the retro-nasal cavity as practically an accessory nasal chamber, and the management, therefore, of inflammatory conditions of its membrane will be governed by the laws which regulate the treatment of catarrhal affections of the nasal passages. These will be fully discussed in the Appendix.

Of prime importance is the hygienic management of this affection. Next in efficacy is the surgical—not a meddlesome surgery—but a surgery inspired by [illegible] conception of the physiological importance and [illegible] logical conditions of the structures to be dealt with. [illegible] reliance can be placed on topical applications. While in some cases they accomplish all that can be desired, in many others they are worse than useless and may tend even to aggravate the inflammatory condition. (For the treatment of Catarrhal Inflammation of the Nose, see article on Chronic Nasal Catarrh, in the Appendix; also the one on Catarrh, Nasal, vol. ii.)

Atrophy.—Concerning the etiology and pathological nature of this condition, see articles just mentioned.

The disease is most frequently met with in adults or in old persons, rarely in children. Occasionally it seems to develop at some physiological epoch, as at the age of puberty, in subjects whose blood is contaminated by some constitutional taint or whose nutrition is impaired from insufficient nourishment or improper hygienic surroundings. In most instances it is the sequel of a pre-existing chronic retro-nasal, pharyngeal, or nasal catarrh.

The condition of the mucous membrane, as revealed by rhinoscopy, is one of atrophy, either affecting the whole region, or confined to individual portions, as the pharyngeal tonsil, the posterior wall, orifices of the posterior nares, fossæ of Rosenmüller, etc. The tenuity of the membrane is sometimes so great that the underlying muscular fibres may be easily distinguished.

The microscope reveals a process of contraction of the different layers of the mucous membrane; partial or total disappearance of the glandular elements, degenerative changes (fatty degeneration, total loss) of the epithelium, and the development of dense fibrous bands from hyperplasia of the submucous connective tissue.

The principal symptoms are excessive dryness of the throat, and, in many instances, a disagreeable odor of the expired breath. In other cases the secretion is more profuse, and the same tendency to crust-formation exists, which will be considered under the head of Chronic Nasal Catarrh, in the Appendix. The removal of crusts from this region often takes place with considerable difficulty, and can in some instances only be accomplished by instrumental aid.

The disease is incurable. Relief to the symptoms can almost always be obtained by stimulating the healthy tissues to vicarious action and by thorough, systematic cleansing of the retro-nasal space (see article mentioned above), but restoration of function in the atrophied structures is obviously out of the question.

John Noland Mackenzie.

[1] Ziemssen's Cyclopædia, Am. Ed. (Buck), vol. vii., p. 33, 1876.
[2] Op. cit., p. 41.
[3] See article on Etiology of Chronic Catarrhal Affections, vol. iv., p. 406; also, Trans. Am. Laryngological Assoc., 1885.

NOSE, ANATOMY AND PHYSIOLOGY OF THE. The nose is the special organ of the sense of smell. Besides this it performs other important functions, and through its free communication with the cavities of the pharynx, mouth, and lungs is concerned in respiration, voice production, and taste. Through the muscles upon its exterior it assists to some extent in the production of expression. It consists of two parts: one external, the nose; the other internal, the nasal fossæ.

The nose is the anterior and prominent part, composed of bone, cartilages, and muscles which slightly move the cartilages. It is of triangular form, directed vertically downward, and projects from the centre of the face immediately above the upper lip. Its summit is connected with the forehead. It possesses two orifices, the anterior nares, which open downward. The lateral surfaces of the nose form by their union the dorsum, the direction of which varies in different individuals. The dorsum terminates below in a rounded eminence, the lobe of the nose.

The nose is composed of a framework of bones and cartilages, covered externally by integument, internally by mucous membrane, and supplied with vessels and nerves. The bony framework occupies the upper part of the organ. It consists of the nasal bones and the nasal

processes of the superior maxillary. The cartilaginous framework consists of five pieces, the two upper and the two lower lateral cartilages, and the cartilage of the septum. The upper lateral cartilages are situated in the upper part of the projecting portion of the nose, immediately below the free margin of the nasal bones. Each cartilage is flattened, and triangular in shape. Its anterior margin is thicker than its posterior, and is connected with the lateral cartilage of the opposite side above, and with the cartilage of the septum below. Its inferior margin is connected by a fibrous membrane with the lower lateral cartilage. The posterior edge is inserted into the ascending process of the superior maxilla and the free margin of the nasal bone. One surface looks outward, the other inward toward the nasal cavity. The lower lateral cartilages are thinner than the preceding, below which they are placed, and are curved in such a manner upon themselves as to form both the inner and the outer walls of each orifice of the nostril. By this arrangement they serve to keep the nostrils open. The outer portion is somewhat oval and flattened, or irregularly convex externally to correspond with the ala of the nose. Behind, they are attached to the margin of the ascending process of the superior maxilla by a tough fibrous membrane, in which are two or three cartilaginous nodules, the cartilagines minores, or sesamoid cartilages; above, they are fixed, "also by fibrous membrane," to the upper lateral cartilages, and to the lower anterior part of the cartilage of the septum. Their outer extremity, free, rounded, and projecting, forms,

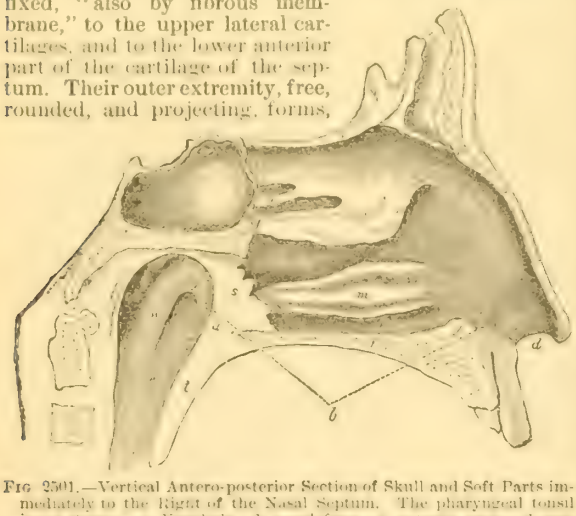


Fig. 2501.—Vertical Antero-posterior Section of Skull and Soft Parts immediately to the Right of the Nasal Septum. The pharyngeal tonsil is not shown. *a*, Vestibule; *b*, nasal fossa; *c*, anterior naris; *d*, nostril; *e*, naso-pharyngeal cavity; *f*, floor of nasal fossa, raised in front into the eminence *g*; *h*, roof of nasal fossa, anterior ascending portion; *i*, roof of nasal fossa, middle horizontal portion; *j*, roof of nasal fossa, posterior descending portion; *k*, superior turbinated body; *l*, middle turbinated body; *m*, inferior turbinated body; *n*, anterior border, middle turbinated body; *o*, inferior border, middle turbinated body; *p*, inferior meatus; *q*, middle meatus; *r*, superior meatus; *s*, posterior part of septum, left *in situ*; *t*, soft palate and uvula; *v*, Eustachian orifice; *w*, salpingo-pharyngeal fold; *x*, roof of naso-pharynx; *y*, Eustachian cushion; *z*, salpingo-palatine fold; *aa*, fossa of Rosenmüller. (Cresswell Baber.)

with the thickened integument and subadjacent tissue, the lobe of the nose. The lower and most prominent part of the ala of the nose, like the lobule of the ear, is formed of thickened skin with subjacent tissue, and is unsupported by cartilages.

The cartilage of the septum has a somewhat triangular outline, and is thicker at the edges than near the centre. It is placed nearly vertically in the middle line of the nose, and completes anteriorly the separation between the nasal fossæ. The anterior margin of the cartilage, thickest above, is firmly attached to the back of the nasal bones near their line of junction. Below this it lies successively between the upper and lower lateral cartilages, united firmly with the former and loosely with the latter. The posterior margin is fixed to the lower and central plate of the ethmoid bone, and the lower margin is received into the groove of the vomer, as well as into the median ridge between the palatal processes of the superior maxillæ.

That part of the nasal canal which is surrounded by the anterior cartilages of the nose, as above described, is sometimes called the vestibulum nasi. It is covered with a continuation of the exterior skin, which gradually assumes the characteristics of a mucous membrane, and possesses several layers of pavement epithelium, the uppermost of which is composed of horny cells. This epithelium extends backward to the anterior margin of the inferior turbinated body and the inferior meatus, where it becomes ciliated. The integument has also vascular papillæ, with both simple and compound loops, and, in the lower part of the nose, long, stiff hairs, called vibrissæ, as well as large sebaceous follicles. It is sparingly supplied with blood-vessels. The nerves are derived from the trigeminus, and consist of filaments, which probably end in terminal bulbs.

The nasal fossæ proper,* with the exception of a limited

* The following description of the bony structures of the nasal cavity, from Gray's Anatomy, is subjoined, in order to render the general description more clear:

"The nasal fossæ are two large irregular cavities, situated in the middle line of the face, extending from the base of the cranium to the roof of the mouth, and separated from each other by a thin vertical septum. They communicate by two large apertures, the anterior nares, with the front of the face, and with the pharynx behind by two posterior nares. These fossæ are much narrower above than below, and in the middle than at the anterior or posterior openings; their depth, which is considerable, is much greater in the middle than at either extremity. Each nasal fossa communicates with four sinuses, the frontal above, the sphenoidal behind, and the maxillary and ethmoidal on either side. Each fossa also communicates with four cavities: with the orbit by the lachrymal canal, with the mouth by the anterior palatine canal, with the cranium by the olfactory foramina, and with the spheno-maxillary fossa by the spheno-palatine foramen; and they occasionally communicate with each other by an aperture in the septum. The bones entering into their formation are fourteen in number: three of the cranium, the frontal, sphenoid, the ethmoid, and all the bones of the face, excepting the malar and lower jaw. Each cavity is bounded by a roof, an inner, and an outer wall.

"The upper wall or roof is long, narrow, and concave from before backward; it is formed in front by the nasal bones and nasal spine of the frontal, which are directed downward and forward; in the middle, by the cribriform lamella of the ethmoid, which is horizontal; and behind, by the under surface of the body of the sphenoid and sphenoidal turbinated bones, which are directed downward and backward. This surface presents, from before backward, the internal aspect of the nasal bones; on the outer side, the suture formed between the nasal bone and the nasal process of the superior maxillary; on their inner side, the elevated crest which receives the nasal spine of the frontal and the perpendicular plate of the ethmoid, and articulates with its fellow of the opposite side; while the surface of the bones is perforated by a few small vascular apertures, and presents the longitudinal groove for the nasal nerve; farther back is the transverse suture, connecting the frontal with the nasal in front and the ethmoid behind, the olfactory foramina and nasal slit on the under surface of the cribriform plate, and the suture between it and the sphenoid behind; quite posteriorly are seen the sphenoidal or superior turbinated bones, the orifices of the sphenoidal sinuses, and the articulation of the ala of the vomer with the under surface of the body of the sphenoid.

"The floor is flattened from before backward, concave from side to side, and wider in the middle than at either extremity. It is formed in front by the palate process of the superior maxillary; behind, by the palate process of the palate bone. This surface presents, from before backward, the anterior nasal spine; behind this the upper orifice of the anterior palatine canal; laterally, the elevated crest which articulates with the vomer; and behind, the suture between the palate and superior maxillary bones, and the posterior nasal spine.

"The inner wall or septum is a thin vertical partition, which separates the nasal fossæ from one another; it is occasionally perforated, so that the fossæ communicate, and it is frequently deflected considerably to one side. It is formed, in front, by the crest of the nasal bones and nasal spine of the frontal; in the middle, by the perpendicular lamella of the ethmoid; behind, by the vomer and rostrum of the sphenoid; below, by the crest of the superior maxillary and palate bones. It presents, in front, a large triangular notch, which receives the triangular cartilage of the nose; above, the lower orifices of the olfactory canals; and behind, the guttural edge of the vomer. Its surface is marked by numerous vascular and nervous canals, and the groove for the nasal branch of the nerve, and is traversed by sinuses corresponding to the bones of which it is formed.

"The outer wall is formed, in front, by the nasal process of the superior maxillary and lachrymal bones; in the middle, by the ethmoid and inner surface of the superior maxillary and inferior turbinated bones; behind, by the vertical plate of the palate bone, and internal pterygoid process of the sphenoid. This surface presents three irregular longitudinal passages, or meatuses, formed between three horizontal plates of bone that spring from it; they are termed the superior, middle, and inferior meatuses of the nose. The superior meatus, the smallest of the three, is situated at the upper and back part of each nasal fossa, occupying the posterior third of the outer wall. It is situated between the superior and middle turbinated bones, and has opening into it two foramina, the sphenopalatine at the back of its outer wall, the posterior ethmoidal cells at the front part of the upper wall. The opening of the sphenoidal sinuses is usually at the upper and back part of the nasal fossæ, immediately behind the superior turbinated bone. The middle meatus is situated between the middle and inferior turbinated bones, and occupies the posterior two-thirds of the outer wall of the nasal fossa. It presents two apertures. In front is the orifice of the infundibulum, by

but important part known as the olfactory region, may be regarded as a continuation of the respiratory tract. The respiratory region, as it is called, is that part which is situated below the olfactory region, and embraces the inferior two-thirds of the septum and the middle and inferior turbinated bodies. Each fossa communicates with four sinuses, the frontal, the sphenoidal, the maxillary, or antrum highmorianum, and the posterior ethmoidal.

The mucous membrane covering the respiratory region and its accessory sinuses is called the Schneiderian, or pituitary membrane. It is devoid of papillæ, and is covered with cylindrical ciliated epithelium, like that of the trachea. The ciliary current is directed posteriorly, toward the pharynx. It contains, also, the so-called goblet-cells. Under the epithelium is a true membrana mucosa. This forms at the same time a periosteum for the bones, and it is composed almost entirely of connective tissue, scantily permeated, if at all, with elastic tissue elements. The mucous membrane may be divided into two varieties: a thinner membrane covering the internal surface of the turbinated bodies and the accessory sinuses, and the thicker membrane of the nasal fossæ proper.

The thinner membrane contains many acinus glands. In the adjacent cavities they are less abundant, excepting upon the internal wall of the maxillary sinus. Here and

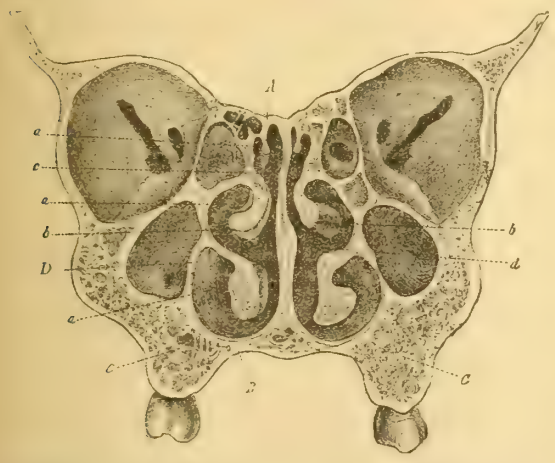


Fig. 2502.—Vertical Transverse Section through the Nasal Fossæ, somewhat behind their Centre. *A*, Roof of nasal cavity; *B*, floor of nasal cavity; *C*, *C*, alveolar processes; *D*, external wall of nasal cavity; *a*, *a*, *a*, three meatuses; *b*, *b*, middle turbinated bodies; *c*, olfactory slit; *d*, respiratory region. (Zuckerkandl.)

in the sphenoidal sinus the glands consist of several cylindrical tubes with connecting single oblong acini. The epithelium of the latter is pyriform, while in the tubes it is cylindrical. The mucous membrane itself is pale in color and scantily supplied with blood-vessels. Special nerve-terminations have been described in these sinuses. They are probably nothing more than terminations of fibres from the great sympathetic, having at their extremities ganglionic cellules.

The thicker membrane covers the lower part of the nasal septum and the middle and inferior turbinated bodies. It is lined with the same ciliated epithelium, and in the anterior two-thirds of the turbinated bodies forms only a delicate, slightly corrugated covering for the subjacent parts. Posteriorly, however, its surface is thrown into numerous thick folds, evidently designed to increase the extent of surface of the mucous membrane. The mucous membrane covering the septum is thicker in the olfactory than in the respiratory region. This thickening is especially marked at the anterior entrance to the olfactory slit, opposite the anterior end of the middle turbinated body, where the accumulation of glandular elements leads to the formation of a distinct prominence, the so-called *tuberculum septi*.

The membrana mucosa forms a fibrous net-work, which passes between the glands and vessels and connects the mucous membrane with the periosteum. Its characteristics resemble more nearly those of periosteum, so that, properly, it may be classed as a part of the latter. The glands of this region vary somewhat from the acinous type and are composed of tortuous tubules having many sinuses and oblong offshoots. They are lined in their inner surface with low, cylindrical epithelium, and sometimes assume a circular, sometimes an oval or tubular shape in the microscopical section. The thickness of the pituitary membrane is due not only to its mucous glands but, more particularly, to the existence in it of true erectile tissue. This was pointed out several years ago by Dr. H. J. Bigelow, of Boston, who demonstrated an abundant and true cavernous structure in and about the turbinated bodies, occupying the place of what before had been supposed to be only venous sinuses, the loops of Kohlrausch. The new result obtained by Dr. Bigelow was due to a different mode of preparation: Kohlrausch injected from the jugular vein, while Bigelow inflated the tissue locally. This erectile tissue is most abundant at the posterior extremity of the inferior turbinated bodies, although it is found throughout their whole length, particularly in front, as in the middle turbinated body and in the lower part of the nasal septum. According to Voltolini the erectile tissue is not confined to the posterior extremity of the inferior turbinated body, as supposed by Kohlrausch, but extends over the whole of that organ. The framework of the erectile substance consists of connective-tissue fibres, with many connective-tissue corpuscles, and fibres of elastic tissue. The blood-vessels are provided with endothelium, but are devoid of any other coats. The spaces formed by the vessels, lacunæ, are few but of large size in the anterior part; whereas, at the posterior part of the turbinated body they are smaller but more abundant. Where the erectile tissue is less abundant the remaining space is almost entirely occupied by large mucous glands. A vertical section of the anterior part of the inferior turbinated body shows that the bony support contributes only about one-twentieth part of the whole body, the remainder consisting of erectile tissue.

In the bony framework of the inferior turbinated body large, bright interspaces are seen in the fine trabecular substance, which are filled with fibrous tissue containing fine lymphoid cells. In this fibrous tissue are usually found transverse sections of delicate vessels, the walls of which are apparently composed of fibrous tissue. In order to reach the outer surface these vessels either perforate the bone or lie in recesses separated from the soft parts only by the periosteum. In the middle three-fifths of the bone, where the osseous structure contains the largest cavities, are found in the vicinity of the vessels large round and polygonal, glistening cells, analogous to marrow-cells. A recent author believes that most of these are lymphatics.

The arteries of the nasal fossæ are derived from the ophthalmic, which supplies the roof and the ethmoidal and frontal sinuses, and form branches from the internal maxillary, the latter supplying the inferior part of the nasal cavity.

The veins terminate chiefly in the internal jugular, a few, however, communicating with the veins in the interior of the skull through the cribriform plate of the ethmoid.

The lymphatics join the retro-pharyngeal glands and others beneath the upper part of the sterno-mastoid. Some also enter glands situated on the surface and in the substance of the parotid gland.

The nerves of general sensation are as follows (Fig. 2503): The nasal branch of the ophthalmic, *d*, which supplies the upper and anterior part of the septum and the outer wall of the nasal fossa; the anterior branch of the superior maxillary, *c*, which is distributed to the in-

which the middle meatus communicates with the anterior ethmoidal cells, and through these with the frontal sinuses. At the centre of the outer wall is the orifice of the antrum, which varies somewhat as to its exact position in different skulls. The inferior meatus, the largest of the three, is the space between the inferior turbinated bone and the floor of the nasal fossa. It extends along the entire length of the outer wall of the nose, is broader in front than behind, and presents anteriorly the lower orifice of the lachrymal canal.

ferior meatus and the inferior turbinated body; the Vidian nerve and the upper anterior branches of Meckel's ganglion (*a*), supplying the upper and back part of the septum and the superior turbinated body, the naso-palatine nerve, which ramifies on the middle of the septum; and, lastly, the anterior palatine nerve (*b*), which supplies the middle and lower turbinated bodies. All these branches are derived from the fifth nerve, and all, excepting the first named, are connected with its second division.

Branches of the sympathetic are also present in the nasal mucous membrane.

With regard to the physiological function of the nose as related to respiration, three important phenomena take place. During its passage through the nose, the inspired air is (1) warmed; (2) it is furnished with a certain proportion of moisture; (3) it is to a great extent freed from dust.

The extent to which the above changes are effected has lately been investigated by Aschenbrandt, of Würzburg, by the following method. By means of an aspirator of a capacity of five litres, which is connected with one of the nostrils by a glass tube, a certain quantity of air is caused to pass through one nostril and out of the other. Every six seconds one litre of air is passed through the nose, and in thirty seconds the experiment is finished. A thermometer in the glass tube gives the exact temperature of the air as it leaves the nose. This

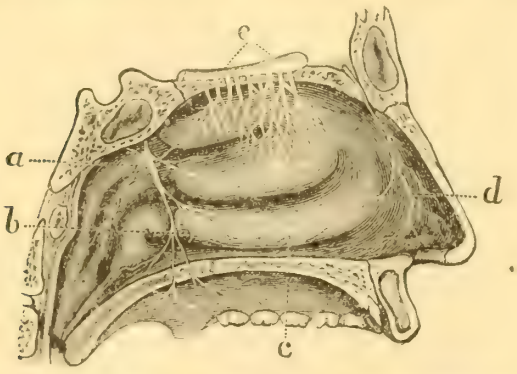


FIG. 2503.—Innervation of the Nasal Cavity. *a*, Meckel's ganglion; *b*, anterior palatine nerve; *c*, anterior branch of the superior maxillary; *d*, nasal branch of the ophthalmic; *e*, olfactory nerve. (Sajous.)

temperature was found to be 30° C. when the temperature of the air in the room was 12°, and he found it to be the same when this was 8°. Now the air when it leaves the nose in ordinary respiration has, as a rule, a temperature of 50° C., which leads to the conclusion that the warming of the air in respiration is done largely by the nose.

The experiments regarding the degree of saturation of the air with water were made with the same aspirator, and in the air which had passed through the nose the amount of water was determined very carefully. It was found to contain 0.18 Gm. in five litres, which corresponds to complete saturation. Accordingly, the whole quantity of water which the air in respiration withdraws from the human body, and which amounts to about five hundred grams, is taken from the mucous membrane of the nose; and the whole loss of heat brought about by the evaporation of that water has to be sustained by the nose, and does not lower the temperature of the lungs, as has generally been supposed by physiologists.

As to the retention in the nose of solid suspended matter, it has been found that the so-called chemical dust, *e.g.*, chloride of ammonia, freshly formed by bringing ammonia and hydrochloric acid together in gaseous form, is not retained in the nose. In experiments made with fine-starch powder, however, not a particle was found to pass through the nose; it was kept back partly in the one nostril through which the air entered, and partly in the naso-pharyngeal cavity.

To meet the objection that in the above experiments the air passed consecutively through both nostrils, they were modified in such a manner that the air was introduced through the mouth, behind the soft palate, by means of a large glass tube. The results were very nearly the same.

These experiments appear to have given a more definite proof than we have had of the threefold function of the nose in respiration. They strongly confirm, also, the opinions now generally held of the danger to the whole respiratory system of nasal obstruction and the habit of mouth-breathing.

When the degree to which the above described functions are influenced by the nasal cavity is appreciated, it will be more easy to understand the intention with which its peculiar structures were planned. Thus, extent of surface being required for the giving off of moisture and the entanglement of dust, the mucous membrane is thrown into extensive folds by means of the turbinated bodies.

Again, no device for the thorough distribution and the speedy replenishment of the blood-supply required to sustain the animal heat lost by rapid evaporation and to impart warmth to the inspired air could be more ingenious and more effective than the dense meshwork of vascular loops which forms the so-called erectile tissue.

D. Bryson Delavan.

NOSE, CONGENITAL AND ACQUIRED DEFORMITIES OF THE. Deformities of the nose may be either congenital or acquired. Of the two the latter are by far the more common.

Congenital deviations from the normal condition of the nose are sometimes found, consisting in absence or reduplication of the whole organ or of any of its constituent parts; in complete or partial closure of its canals; or in abnormalities of size and shape of certain of its parts. With the exception of the last-named conditions, which are common, these abnormalities are rare.

A case of absence of the nose, the only one on record, was mentioned by Maisonneuve, in which the normal organ was replaced by a flat surface, pierced by two small, round holes. The condition of the nasal fossæ was not stated. The malformation of double nose, referred to by the older writers, has not been met with, apparently, in late years, and seems almost worthy of being considered mythical. Absence of the nasal bones, or of the nasal process of the superior maxilla, is sometimes seen. Fissures associated with harelip and cleft palate also occur. The anterior nares are not infrequently found wholly or in part closed. Such occlusions are generally membranous. They occur at different depths. The naso-pharynx is, in rare instances, separated from the nasal fossæ on one or both sides by a lamella of bone, and division of the naso-pharynx has been observed from the septum having extended backward as far as the vertebral column. A case of double septum has been described by Lefferts, in which the upper half of the posterior edge of the vomer was divided in the vertical direction into two distinct parts. These were separated sufficiently to admit the end of a lead-pencil between them. The space thus enclosed was triangular in shape, the widest part being above; the mucous membrane had a natural appearance. In the nasal fossæ themselves are sometimes found congenital defects and malformations of the turbinated bones, of the ethmoid cells, and of the septum, as well as conditions of asymmetry of the whole structure, many of which conditions may also be acquired as the result of nasal obstruction or of syphilis, lupus, or other destructive disease.

Thus, the turbinated bones may exist only in a rudimentary form; or there may be a supernumerary one situated near the roof of the fossa; one of them may be greatly hypertrophied, while the number and degree of variations in their general form and size are almost infinite.

Asymmetry of the nasal fossæ as a whole has been described by Harrison Allen and by Zuckerkandl. In some cases it seems to be congenital, while in others it may possibly be due to a pre-existing stenosis of one nasal fossa, which, while thus deprived of its proper

nutrition, fails to develop in harmony with its fellow. This view, according to Ziem, is strengthened by the results observed after excluding the entrance of air from one nostril in young animals. In these was developed a deviation of the intermaxillary bone, and of the sagittal suture toward the occluded side; there were also shortening of the nasal bone, frontal bone, and horizontal plate of the palate bone of the same side; flattening of the alveolar processes: reduction of the distance between the auditory canal and the alveolar process, as well as between the zygomatic arch and the supra-orbital border; and smaller size and asymmetrical position of the vascular and nerve canals on the closed side of the nose. The distance of the two orbits from the median line was unequal, a condition which, in the human being, is said to lead to asthenopia, astigmatism, and strabismus. Finally, according to some observers, certain curvatures of the spine seem due to nasal obstruction.

From this it seems possible to the writer that defective development of the nasal fossæ, both asymmetrical and symmetrical, may be brought about through obstruction to the respiratory canals by enlargement of the tonsils, hypertrophy of the turbinated tissues, or adenoid vegetations in the vault of the pharynx, in cases where these obstructions have occurred early in life and have been allowed to persist unrelieved.

Deviations of the nasal septum are so common as to be almost the rule. Practically, they are the most important abnormalities of the nose with which the surgeon has to deal.

Observations as to their frequency have been made from the study of dried specimens, by several observers, with the following results:

Theile,	in	117	skulls found deviation in	73.5	per cent.
Semeleder,	"	49	" "	79.5	"
Allen.	"	58	" "	68.9	"
Zuckerkandl,	"	370	" "	37.8	"
Morell Mackenzie,	"	2,152	" "	76.9	"
Delavan,	"	700	" "	19.2	"

Thus, in a total of 3,446 cases there was deviation in 2,095, which would equal about sixty per cent.

In 909 cases out of 1,831 the deflection was toward the left; in 681 toward the right; while in 241 it was sigmoid.

The marked differences shown in the above percentages are probably due to variations in the standards of comparison adopted by the respective observers. Thus, Mackenzie's measurements were made in such a manner as to include deviations not exceeding one-half a millimetre; while in my own, none was recorded in which the deflection did not amount to an absolute obstructive deformity. It will be readily seen, however, that even selecting the severe cases, these deformities are very common. When there are added to them obstructions arising from deviations of the nasal cartilages, the number will be still further increased.

The causes of deviation of the nasal septum are by general consent admitted to be obscure. The idea that they may be of congenital origin is open to serious doubt. Not only has Zuckerkandl maintained that the septum is always straight until the seventh year, but the history of the development of the nasal organ shows that it is, as a whole, one of the last to assume its ultimate form. Watson tells us that in the infant the nasal fossæ are relatively smaller in size, and much less complex, than in the adult; their vertical diameter is remarkably small, the sinuses being not yet formed, and the lateral masses of the ethmoid bone being still cartilaginous. The cribriform plate of the ethmoid at birth is a mere membranous plane, continuous with the falx cerebri of the dura mater, and attached behind to the partially ossified body of the sphenoid. The vertical plate of the ethmoid, in other words, is cartilaginous at this period, while the vomer is already ossified. Some months after birth the nasal fossæ begin to enlarge in all their diameters, and the different sinuses are developed. At the age of two years the frontal sinuses and ethmoidal cells have begun to form, and the hollowing out of the antrum of Highmore goes on simultaneously.

This late development of the central portions of the skull provides not only for a certain amount of mobility in the bones during parturition, but, what is of no less importance, enables the alteration in bulk of the surrounding bones and cavities in the process of growth to go on without any rigid impediment in the centre, and the full development of the soft tissues, and especially of the nerves, is possible without the risk of compression by the encroachment of osseous deposits in the channels for their transmission.

Again, the turbinated bones are not formed until a late period in the development of the fœtus; indeed, according to Quain, the inferior turbinated bone is ossified from a single centre, which only appears at birth. From what has been said, it is plain that the tardy development of these parts is followed later in the history of the individual by a very considerable activity of growth.

It will also appear that: (*a*) There is an inequality of development at the outset, the vomer being ossified while the perpendicular plate of the ethmoid is still membranous, and the turbinated bones practically yet unformed. (*b*) That the process of development goes on with great rapidity at certain periods after birth. (*c*) That any condition of over-development is not probable before the age of seven years. (*d*) Again, the posterior free border of the vomer, looking toward the pharynx, is almost invariably straight. This may be accounted for by the fact that this portion of the bone is also particularly thick and strong; its vertical diameter is decidedly less than that of the more anterior part; and, finally, it is so situated as not to be exposed to injury. It therefore seems reasonable to suppose that the straight position is the one assumed at the outset, and that it is here maintained by reason of the inherent strength of this part of the vomer, by its short diameter, and by its protected situation.

The anterior aspect of the vomer, for exactly contrary reasons, is liable to displacement. This may result from one of two entirely distinct and separate causes. The first of these is traumatism. In a series of examinations made by Dr. J. W. Robertson, of Detroit, it was found that of 217 cases of nasal deformity 83 gave a history of injuries having been received; and of the remainder, which gave no such history, one-half had received injuries in early life which had been forgotten, since many of them had dislocations of the cartilages and fractures of the nasal bones which could only have been the results of external violence. It would appear from the foregoing that a large percentage was directly due to traumatism. As to the ages at which these deformities occurred, in a total of 161 children from two to ten years of age only 7 deformities existed; 4 of these gave a history of injury. In 72 individuals between ten and twenty there were found 22 deformed noses; of these 6 gave a history of injury, while in 16 the causes were unknown, although 5 had dislocation of the septum and one had disarticulation and depression of the nasal bones. A number of the above cases, not due to injury, gave histories of syphilis, scrofula, or tuberculosis. It would appear, therefore, from these statistics, that a large proportion of nasal deformities manifest themselves between the ages of ten and twenty, a period of great constructive activity, either through the receipt of injuries, or through improper development due to malnutrition.

These considerations all point directly to the inference that the septum, made up as it is of several plates unequal in strength and in the power of resisting compression, uneven also in development, and finally, incased in an unyielding cavity closed by the ethmoid above and firmly buttressed by the arch of the palate below, bends in the direction of the least resistance, and, as the process of growth goes on, over-development is thereby attended with a pushing aside of the various parts from their normal planes, and the production of a deflection of greater or less degree. It is probable that many of the so-called congenital deflections may be thus explained.

As to the varieties of deflection which are found, it will be proper to consider, first, those of the cartilaginous septum; secondly, deviations of the bony septum; and finally, those of the entire septum, cartilaginous as well as bony.

Deviations of the cartilaginous septum have been explained as due to various extraneous causes, as, for example, always blowing the nose with the same hand and thus forcing it to one side; habitually sleeping with the same side of the face on the pillow, etc. This may possibly explain some of the deformities of the lower lateral

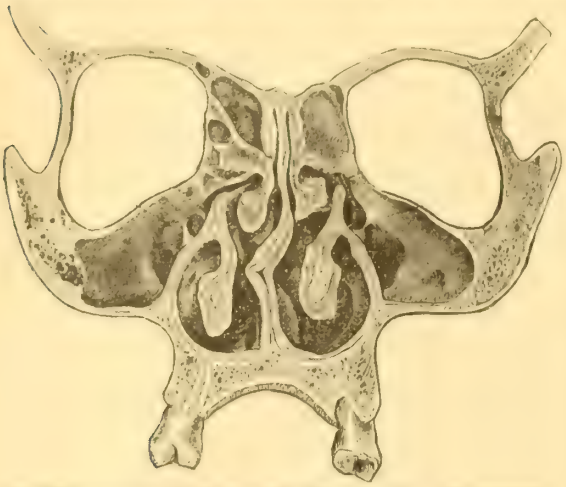


Fig. 2504.—Angular Deflection of the Nasal Septum. (Zuckerkandl.)

cartilages described by Loewenberg, in which these cartilages are disturbed as to their normal relations with the median line, and thus the lobe of the nose is turned to one side, or the nostrils are distorted or narrowed. The majority of them, however, are probably the result of direct injury. Deflections of the cartilage of the septum itself are also due, in most instances, to traumatism. Thus, the cartilage may be fractured; or, as more often happens, dislocated. In such cases the result will be a distortion of the tip of the nose, which will be turned toward the direction of the lower margin of the dislocated cartilage, and occlusion, greater or less, of the opposite naris, or even of both nares, the cartilage lying directly across the plane of the septum. Such dislocations, both recent and of long standing, are not uncommonly met with.

Again, the cartilage may be bent upon itself, in either

Fig. 2505.—Slight Curvilinear Deflection of the Nasal Septum, not sufficiently pronounced to be Pathological. (Zuckerkandl.)

a vertical or horizontal position, presenting along the line of the bend a ridge sufficiently prominent to occlude the naris. The horizontal bending is by far the most common, and, at the same time, it is apt to be the most pronounced. Corresponding with the convexity of the bend will often be found a deep concavity in the opposite nostril. This condition may extend for a considerable distance backward, or sometimes backward and upward, involving the vomer. It is capable of causing serious obstruction to respiration, and great consequent annoyance.

Deflections of the bony septum, extending farther backward and upward than the above, are of common occurrence. It is necessary to distinguish, not only their existence, but, in addition, to estimate the probable amount

Fig. 2506.—Extensive Deflection of the Nasal Septum, with Narrowing of the Transverse Diameter of the Nasal Fossæ and Marked Irregularity of the Turbinated Bodies: Serious Occlusion of the Nasal Canals. (Zuckerkandl.)

of obstruction they are likely to cause. Many of them, such as the one illustrated in Fig. 2505, are comparatively harmless, giving rise to no symptoms, and therefore calling for no interference. In other cases, however, owing to an increase in the amount of deflection and, perhaps, to hypertrophy of the adjacent soft parts, the nasal fossæ become so seriously occluded as to call urgently for relief. As in the case illustrated in Fig. 2506, the whole cavity both above and below is effectually narrowed; the respiratory passages are practically useless, and the olfactory region is so shut off from the inspired air that the odorous particles cannot reach it, and thus, even although

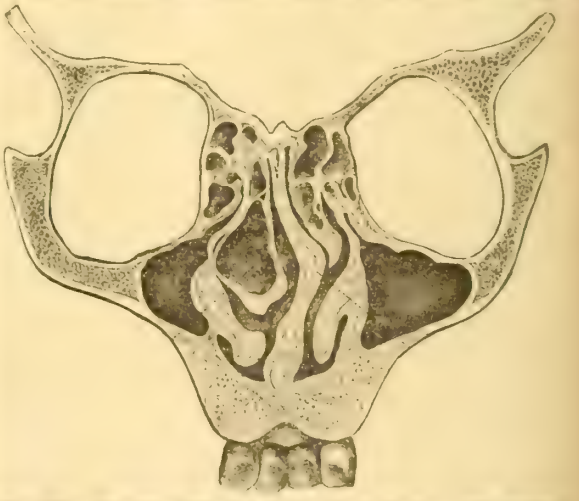


Fig. 2507.—Extensive Deflection of the Nasal Septum, with Marked Hypertrophy of the Middle Turbinated Bone opposite the Concavity of the Deflection: Serious Occlusion of the Nasal Canals of both Sides.

the olfactory mucous membrane may of itself be capable of performing its function, the sense of smell is practically lost.

In still another class of cases (see Fig. 2507) an extensive deflection will be found opposite the level of the mid-

dle turbinated body, and combined with this deflection a corresponding enlargement of the middle turbinated bone itself. The attention of the writer was called to this fact in 1880, while dissecting a recent specimen. The importance of the condition at once suggested itself, and a somewhat extensive and long-continued series of observations was made, for the purpose of investigating the actual nature and pathological significance of the deformity, and the relative frequency with which it occurred. Accordingly, seven hundred well-preserved specimens, selected from several of the best craniological collections known—namely, the Blumenbach collection in Göttingen, the Hyrtl collection, now in Philadelphia, and the Spurzheim and Peabody collections of Harvard University, together with several smaller ones—were carefully examined, and the following data obtained :

Of the whole number of specimens examined, 700, there was deflection of the septum in 134, or 19½ per cent. Of these 134, there was hypertrophy of the middle turbinated bone in 69, or 10 per cent. of all cases ; or, of the whole number of cases of deflected septum, 134, there was hypertrophy of the middle turbinated body in 69, or 51¾ per cent.

No case was included in which the deflection was not well marked, and of pathological importance. It will thus be seen that more than one-half of the above cases of deflection of the bony septum showed hypertrophy of the middle turbinated bone. The actual percentage of cases of hypertrophy is probably even greater than that given, as in several specimens examined, in which deflection existed, the middle turbinated bones were wanting. In many instances the writer has demonstrated the presence of this bony hypertrophy in the living subject by sounding, as it were, the enlarged mass with a fine needle, and observing the depth at which its point was arrested. Instead of entering the mass to some distance, as would be expected, it will often impinge upon the bone at a point comparatively near the surface. In several museum specimens examined, the turbinated bone approached so near to the septum that a probe could hardly be swept between them. The wider naris was thus more completely occluded than the one on the convexity of the septum, a fact often noticed in the living subject. As to the relation of cause and effect in these cases, between the deflection of the septum and

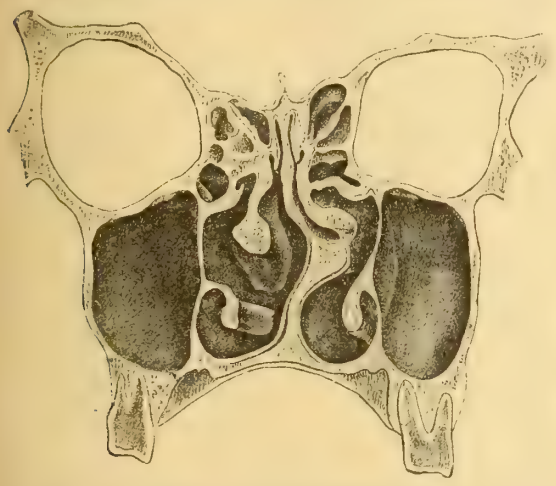


Fig. 2508.—Osseous Ridge of the Nasal Septum, causing Occlusion of the Nasal Canal. (Zuckerkandl.)

the hypertrophy of the turbinated bone, it seems probable, as was suggested by the writer, in an article published in 1882, that the deflection takes place first in the course of events. This, by reason of the undue widening of the nasal canal, is followed by hyperæmia of the neighboring vessels, and by frequent turgescence of the soft tissues covering the middle turbinated bone ; and, since this turgescence is unrestricted by the normal limits of the nasal cavity, it becomes more marked in degree as well as in frequency of occurrence, and through this process, and the attendant hypernutrition, a true bony hypertrophy is produced. The nature of the hypertrophy is peculiar. The bone is not increased in density, but seems to expand into a thin plate of shell-like texture which is, as a rule, easily broken or crushed.

There is a deformity of the septum which may occasion much obstruction to the inferior region of the nasal cavity, and yet which cannot properly be called a deflection. It is the development, at or near the sutural line of the vomer and the palatal process of the maxilla, of a bony or cartilaginous ridge (see Fig. 2508). This ridge or spur may be a limited, rounded excrescence, resembling a true osseous tumor or exostosis ; or, it may extend horizontally from a point in the nares well anterior to a considerable distance backward. It may be wholly limited to one side ; or, it may be developed more or less symmetrically on both sides. A slight tuberosity anteriorly may be considered as normal.

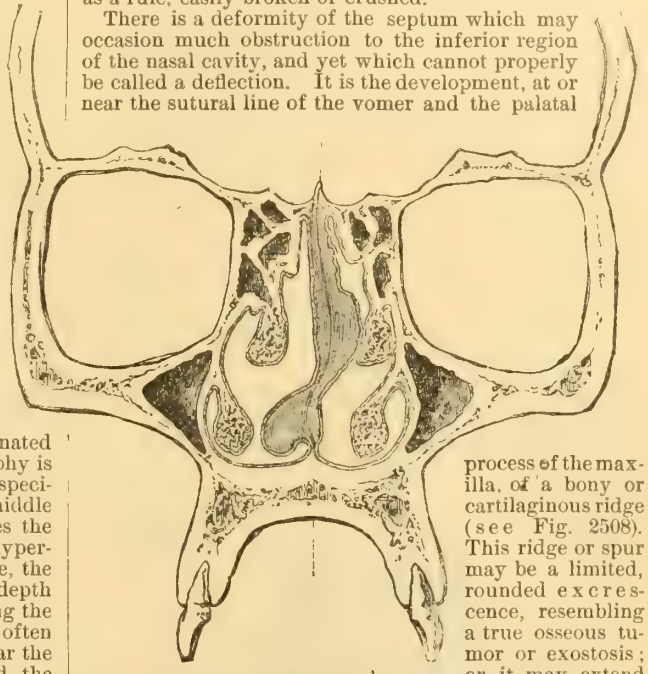


Fig. 2509.—Sigmoid Deflection of the Nasal Septum. (Woakes.)

This crest often gives rise to great annoyance by lessening, in company with the adjacent inferior turbinated body, the normal diameter of the inferior nasal canal, exciting catarrhal thickening of the overlying mucous membrane, and thus producing a marked occlusion at the very entrance of the respiratory passage. Now and then a similar ridge will be found along the line of the sutures which unite the cartilaginous septum with the vomer, or even along the suture between the latter bone and the perpendicular plate of the ethmoid, or, again, between the ethmoid bone and the cartilage. Many causes have been adduced for this particular class of nasal deformities. By none of them, however, does their origin seem satisfactorily explained. It is possible that they may be due to severe forms of catarrhal inflammation of the adjacent mucous membrane, which, by attracting an undue supply of blood to the region, sets up a condition of hypernutrition in the thicker parts of the bone which results in overgrowth and consequent deformity.

Still another group of deviations are those in which the septum exhibits a double curve, forming the so-called sigmoid flexion (see Fig. 2509). In this a deflection along the line of junction of the vomer with the palatal process of the superior maxillary bone is associated with a marked curve in the opposite direction in the upper part of the vomer and the perpendicular plate of the ethmoid. This form is of frequent occurrence.

In the case of a boy, aged sixteen, operated upon in the presence of the writer, by Dr. Charles H. Knight, of New York, the following extraordinary and interesting condition was observed : No history of traumatism, but marked external deformity, the nose being flattened somewhat, and twisted sharply to the left. The right side was

free, with deep concavity of the septum. The left side was absolutely occluded by an extensive deflection, the convexity of which was in close relation with the nasal process of the superior maxillary bone. Upon attempting to reduce the deflection, the septum was found to be firmly and extensively attached by bony union to the nasal process, from which it was necessary to forcibly detach it before the septum could be replaced.

Associated with deflection of the septum is sometimes found a peculiar high-arched condition of the hard palate, which is narrowed in its transverse diameter, so that the arch of the roof of the mouth is markedly raised, and the level of the floor of the nose considerably altered, while the normal rounded contour of the anterior arch is sharpened into a more distinctly angular shape, which throws the upper front teeth forward and gives a characteristic expression to the face. This condition is frequently associated with the habit of mouth-breathing, and is probably due to faulty nutrition of the parts, in some way not yet explained. From the fact that it is often found as a family or race peculiarity it is safe to believe that it is, in many cases at least, distinctly hereditary. It is said to be more common among those possessing noses of the purely Grecian type, in which the bridge of the nose is thrown well forward, and in a line with the forehead. It is also met with in noses of the Roman order. In these, again, the nasal processes of the superior maxilla are prominent.

Synechia, or fusion of one part of the nasal fossæ with another, is occasionally found. Instances, however, are

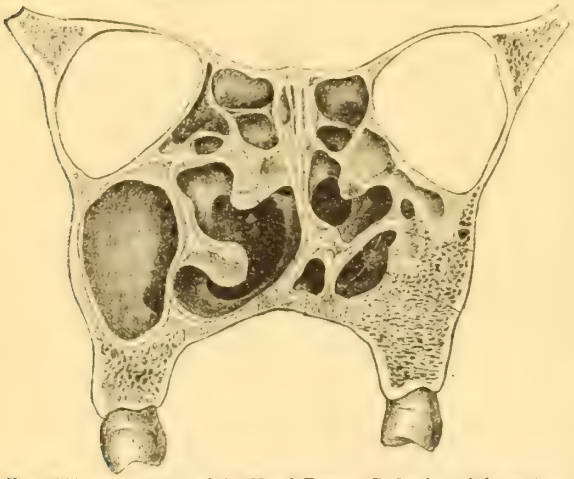


FIG. 2510.—Asymmetry of the Nasal Fossæ. Deflection of the septum; synechiæ of the middle turbinated bone with the septum; of the right inferior turbinated bone with the septum, and with the floor of the nasal fossa. (Zuckerkandl.)

rare in which it has not been produced as a result of some previously existing destructive process, as, for example, syphilis or lupus.

The junction is sometimes made merely by continuity of the investing mucous membrane; sometimes by true bony union. According to Morell Mackenzie, four chief varieties of synechiæ seem to occur:

(1) Membranous bridges spanning the interval between two opposite surfaces—*e.g.*, between the middle turbinated body and the septum; (2) broad membranous junctions between the mucous covering of one of the turbinated bodies and the outer wall of the nasal fossa, or between the corresponding angles of neighboring turbinated bodies; (3) osseous bridges connecting one of the turbinated bones with the septum; (4) wide, bony union between the edge of the lower turbinated bone and the floor of the nose. All these varieties, or any number of them, may coexist, and any one of them be found in several places. (See Fig. 2510.) Synechiæ are occasionally symmetrical, being present in both nasal fossæ in corresponding situations. That such conditions are not necessarily congenital is suggested by the occasional coexistence of a perforation of the septum.

In a case which has lately come under the observation of the writer, in which there was almost complete occlusion of one naris posteriorly by extensive synechiæ, with perforation of the septum, the patient had had syphilis.

Finally, asymmetry, septal deflection, and synechiæ may be associated in the same case.

From what has already been said it is clear that these various conditions of nasal deformity may occasion obstruction to the nasal passages, and hence to the function of respiration, which will be more or less serious in proportion to its degree. Mouth-breathing, with all of the disastrous consequences of insufficient aeration of the blood; catarrhal conditions of the nasal passages, pharynx, larynx, and bronchi; loss or impairment of auditory and olfactory sensibility; reflex symptoms, near and remote, in great variety, as, for instance, cough, vertigo, chorea, epilepsy, laryngeal spasm, and many more besides—all have been caused by nasal obstruction. Moreover, loss of the olfactory sense is in many of them inevitable, simply by reason of the mechanical obstruction which they offer to the ingress of the odorous particles. Thus, it will be seen that their influence covers a wide range, and that their removal is of vital importance to the general nutrition and well-being of the patient.

Since there exists among them such great variety in form, position, and degree, the treatment of deformities of the nasal fossæ and of deviations of the nasal septum must be selected with reference to the particular case in hand. From what has been demonstrated it will be seen at once that no single method of operation is applicable to all. It will be well, therefore, to study first the various plans of treatment and of operation which have been employed; and, secondly, to suggest the possibilities and the limitations which belong to each.

As to the congenital deformities referred to in the early part of this article, those consisting of a closure of the anterior nares, or of bony separation of the nasal fossæ from the naso-pharynx, are the most important, since, by occluding the nasal passages, they directly menace the infant's life. It is necessary, therefore, to recognize them at once, and, if possible, to restore the patency of the only channel through which the child, while nursing, can breathe. A passage must be forced through with a strong probe, or with the galvano-cautery, and the opening gradually dilated and kept open by the passing of suitable bougies. Tents of laminaria would probably serve a useful purpose in cases in which the occlusion is not situated too far backward.

Such a case as that described by Maisonneuve would of course require an extensive rhinoplastic operation. Cases of fissure, combined with hare-lip, could hardly be relieved without important surgical interference, and belong more properly to the department of uranoplasty. Asymmetry is of itself an irremediable condition. That its more distressing symptoms may be removed will be seen later on.

Deviations of the septum are as common as the above anomalies are rare, and it is to their treatment that the attention of the surgeon will be most often directed. Malpositions of the nasal cartilages themselves, and even slight deviations of the cartilaginous septum, may be relieved to some extent in many cases by carefully directed pressure, the parts being moulded, as it were, into their normal shape. This proceeding is of great antiquity, as it is said by Herodotus to have been practised among the Persians in the time of Cyrus. Few cases, however, will be found amenable to such mild treatment. A peculiar flaccidity of the alæ of the nose, which allows them to be drawn inward with each inspiration, is often met with. In the presence of this condition, an otherwise pervious nasal fossa is occluded, and much annoyance is occasioned. Thus far no remedy has been proposed for it, although it may be relieved temporarily by the separation of the parts through the introduction between them of a piece of small india-rubber tubing.

An easy operation in simple cartilaginous deflection, recommended by Dr. C. E. Sajous, of Philadelphia, is

an incision through the protuberance following its long axis. The end of the finger is introduced into the nostril, and the septum forcibly pushed beyond the centre and held there by packing the previously obstructed nostril with oakum or other suitable dressing. The dressing should be changed daily, and both nares sprayed with an antiseptic solution. Again, in simple deflections of the cartilage, attended with thickening of its substance and with the existence of a pronounced ridge, sufficient space for breathing purposes may sometimes be obtained by paring away the redundant part with a knife or a saw.

Dr. E. Fletcher Ingals, of Chicago, in certain anterior cartilaginous deviations, suggests that an oblique incision be made through the mucous membrane of the convex part of the prominence, that the membrane on each side of the cut be detached for a certain distance from the underlying cartilage, exposing the latter, and that a triangular piece be then cut out of the cartilages, the base of the triangle being at the floor of the nose. Care should be taken to detach the cut piece from the lining membrane of the other cavity, without tearing or cutting through it. The first incision is then closed by sutures, and the cartilage is supported in the median line by tampons.

Dr. J. B. Roberts, of Philadelphia, describes as follows an operation which has been performed by himself and others, in properly selected cases, with considerable success :

With a scalpel introduced through the obstructed nostril the cartilaginous septum is perforated at its inferior and posterior part, and a long incision is made downward and forward ; this enables the whole cartilaginous septum to be pushed to the left, assuming that the obstruction is in the left nostril, and overcomes, to a great extent, the lateral deformity. To retain the parts in position, a steel pin, one inch and a quarter long, is introduced into the right nostril, and passed completely through the anterior and upper section of the divided septum, near the columella. The movable portion being transfixed, the head of the pin is carried to the left and with it the inferior part of the nose, and thus retained by imbedding the point of the pin deeply in the immovable cartilaginous septum and mucous membrane at the back part of the left naris.

Often two pins will be needed to correct the deformity. In such cases, Dr. Roberts usually inserts the second one, not from the mucous surface within the nostril, but from the cutaneous surface of the dorsum of the nose, just below the nasal bone, having before, if necessary, forced the cartilage loose with a tenotome. The incisions must be very free, in order to take away all resiliency from the cartilage, so that the operation is necessarily a bloody one. The pin should be protected at its free extremity by a small ball of lead, so that the lobe of the nose may not be injured. It is left in position about two weeks.

The advantages of this method are that it is simple, effective, and comparatively free from inconvenience to the patient, who is not annoyed by stoppage of the nose or by disfiguring apparatus.

Probably the most rational operation for deviations of the bony septum, particularly if they be situated well backward and upward from the nostril, is that proposed by Adams, of London, and modified by Steele, of St. Louis. In this a stellate incision is made, by means of an instrument designed for the purpose, through the deflected part of the septum, and the fragments thus produced are forced over to the median line, and there retained in position by a nasal clamp or by the introduction into the nasal canal of something which shall give to the operated part of the septum the necessary support. This, however, is difficult to accomplish on account of the great resiliency of the fragments. The latter difficulty may be overcome by fracturing them at their base, although this procedure is not entirely safe.

Since there is a redundancy of tissue in these cases of deflection, Dr. C. E. Sajous, of Philadelphia, has devised an excellent instrument, by which not only a stellate incision, after the manner of Steele, is made, but a part of the septum is actually removed, so that the fragments can be brought together without overlapping.

For the relief of obstruction caused by ridges or projections of mucous membrane situated well anteriorly, Jarvis, of New York, removes the redundant soft tissue by means of a transfixion-needle and his well-known steel-wire écraseur. In cases where the underlying bony structures are well covered, this may give considerable relief. Where, on the other hand, as generally happens, a true deflection or a bony ridge or spur exists, it can hardly reach the real seat of the difficulty.

In these cases three different plans for the removal of the offending bone have been proposed : first, by the burr of the dental engine ; secondly, by a small, narrow-bladed, fine-toothed saw ; thirdly, by properly adapted osteotomes, either chisel- or gouge-shaped. The first of these methods has been constantly employed in New York for several years ; the others are in common use both here and in Europe, and are the methods generally referred to in recent text-books. A convenient saw for this purpose has been made by Bosworth. Finally, in cases in which the deformity of the septum is too great to admit of an ordinary operation, Dr. John N. Mackenzie, of Baltimore, has operated successfully by removing a sufficient part of one of the lower turbinated bodies to admit of the air being freely inspired.

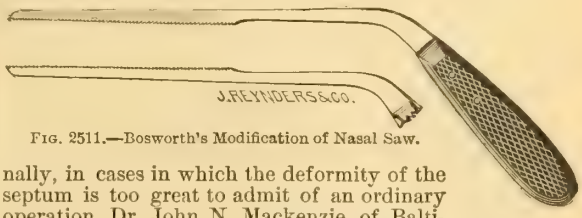


Fig. 2511.—Bosworth's Modification of Nasal Saw.

In the hands of a skilful operator, and in properly selected cases, any of the above methods is admissible, and all are capable of affording relief.

Blandin, of Paris, has advocated the removal of a small round section of the septum by means of a punch made for the purpose. A permanent communication is thus made from one nasal cavity to the other. This procedure is eminently clumsy and unsurgical, and in reality is unjustifiable, as being liable to do more harm than good. In the opinion of the writer it should never be permitted.

The prognosis, of course, depends upon the nature, location, and extent of the deflection. The ends to be attained are, first, the restoration to the nasal chambers of their normal respiratory function ; secondly, the restoration of the olfactory sense ; and, thirdly, the relief, by improving the outward shape of the nose, of a serious cosmetic defect. In some cases the best results may be expected, while in others a moderate degree of success is all that can be attained. Much will depend upon the skill and experience of the surgeon in selecting the method of operation applicable to a given case. From what has been said with regard to operations upon the cartilage, it will appear that, on the whole, Roberts' method promises well in the more pronounced deformities. Comparatively few will be found of so slight a nature as to be helped by less severe treatment. In the experience of the writer the knife cannot be depended upon in attempted incision of the cartilage. In one patient, a girl of only thirteen years of age, the cartilage was found to be ossified to such a degree that a pair of cutting pliers had to be substituted for the scalpel. It is possible that the cicatrix resulting from the removal of the convex surface of a deflected cartilage may, by its contraction, draw the septum in the direction of the original deviation, and thus tend to defeat the object of the operation.

In cases of the nature represented in Fig. 2504, the mucous membrane and periosteum should be raised from the septum, and the osseous tissue then removed with a saw or chisel until a proper plane is reached, after which the soft parts should be replaced, and retained in position in such a way as to best facilitate the process of healing.

Fig. 2506 represents a condition, fortunately unusual, in which such marked irregularities exist that no opera-

tion upon the septum would be likely to afford relief. Here removal of a part of the turbinated bodies, by means of the galvano-cautery or by the dental burr, would probably give the best results.

In cases of deflection of the septum complicated with marked hypertrophy of the middle turbinated bone (Fig. 2507), it will at once be evident as suggested by the writer several years ago, that, upon the simple mechanical principle that two bodies cannot occupy the same space at the same time, the successful replacement of the septum will require, first, the removal of the redundant turbinated bone, either in its entirety or to an extent sufficient to provide the requisite amount of space. Enough of the turbinated body should be left, if possible, to secure the performance of its normal function. This having been done, and the septum reduced to the median line, each nasal fossa will be increased in calibre, and air will be freely admitted both to the lungs and to the region of the olfactory sense.

Bony ridges, as illustrated in Fig. 2508, may be treated conveniently by the saw, the excrescence being removed and the resulting surface allowed to granulate and heal.

With regard to the treatment of sigmoid deflections, little reliable information can be obtained. Much may be done by the application of known methods to relieve the more serious points of obstruction which they present; but, obscure in themselves and difficult to reach, their thoroughly satisfactory management is, at present, a problem the solution of which has not been attained.

Synechiæ, when membranous, may be divided by the galvano-cautery and the superfluous tissue removed; when bony, as in Fig. 2510, by means of the saw or the dental burr, cutting through the osseous bridges, one after another, and thus removing the whole obstruction. Asymmetry is, of itself, irremediable, although there probably are few cases in which the nasal space cannot be widened and the ingress of air facilitated.

The use of cocaine in nasal operations is invaluable. A solution of not less than ten per cent. in strength should be applied until a sufficient degree of anæsthesia is attained. Two or three applications, at intervals of five minutes, will be found satisfactory. In operating upon the septum under cocaine, the drug should be applied to the septum upon both sides.

Among the deformities of the lobe of the nose and its cartilages none is more common and more of a disfigurement than the condition known as "snub-" or "pug-nose." To Dr. John O. Roe, of Rochester, N. Y., is due the credit of having presented to the profession a clear explanation of its causation and pathology, as well as of having first suggested and practised successfully the means for its relief.

Dr. Roe describes three conditions which may occur during the development of the nose to give it this appearance. 1. Excessive development of the alæ and cartilaginous part of the end of the nose. 2. Lack of sufficient development, or a sunken or flattened condition of its base and bridge, while the end may be normally developed. 3. That in which the two former conditions are, to a greater or less degree, combined. The latter is the condition most often found. The bony parts of the nose, as, for instance, the sphenoid bone, are late in their development. At birth the organ at its base and central portions is flat and nearly level with the face. Later this depressed line is replaced by a more prominent one as development proceeds. Anything interfering with the proper development of the parts, in such a way as to cause them to remain in the infantile condition while the end of the nose undergoes due development, will give the nose a pugged and unsightly shape.

The best-developed and most beautiful noses are one-third the length of the face. They often vary, however, from this proportion. An ill-formed nose is sometimes inherited as a special family peculiarity. Indeed, it has been said that of all the features the nose is the one which heredity preserves the best. In other instances, however, it is without doubt due to diseased conditions affecting its growth and proper development during infancy and early childhood.

Many conditions operate to produce this result. Chief among these is obstruction of the nasal passages and the cutting off of nasal respiration. During deglutition and the act of respiration, when the nasal passages are obstructed, a partial vacuum is produced in the naso-pharynx. This suction force being exerted on the inner side of the yielding cartilaginous nasal tissues, tends thereby to draw them inward, and thus, to a corresponding degree, retards or prevents their normal expansion, growth, and development. Obstruction of the nasal passages may also cause an enlargement or undue development of the part of the nose below and beyond, especially if the obstruction be composed of firm tissues, through interference with the return circulation. The end of the nose thus becomes engorged, the vessels distended, and a marked thickening of the tissues takes place. The importance of attention to obstructed nostrils in infants is thus clearly demonstrated. All chronic affections of the nose, especially when attended with obstruction of the passages, tend to produce more or less congestion of the vessels at the end of the nose, and, by reason of these vessels having less power of resistance, undue distention of them takes place. The surrounding tissues become thickened, and enlargement of the end of the nose occurs. This is a matter of common observation in the treatment of nasal diseases.

Again, a deflected septum will tend to lower the outer contour of the nose, as well as to cause an undue arching of the palatine vault.

A pugged appearance may also be given by injuries to the nasal process of the superior maxilla, as well as by destruction from disease of the septum.

The method of correcting the deformity, as proposed and practised by Dr. Roe, is described by him as follows: It consists in removing from the end of the nose that tissue which is in excess, or which is disproportionate in amount to the other parts of the organ; in other words, the nose is to be made symmetrical from one end to the other. In cases where the bridge is low and undeveloped, if the end be lowered, made smaller, and brought down so that the top of the nose forms a straight line from its base or junction of the nasal bones to the end, then the nose ceases to be unduly noticeable or unsightly; and although it will actually be smaller it will appear much larger than before, by reason of its being symmetrical and proportionate throughout. In this way its appearance will be much improved, for disproportion of the nose with the size of the face is not so important as lack of proportion between the different parts of the nose itself. In those cases in which the deformity consists in an undue enlargement of the end of the cartilaginous part of the nose, while the bony framework is normally developed, it will be seen that the main part of the organ is straight until we come to the enlarged end, which suddenly tilts upward. Even in these cases it is not the end of the nose that appears too large, but it is the base or bridge that appears too small or depressed.

The operation is performed as follows: The sensibility of the interior surface of the anterior end of the nose is deadened by cocaine, and then brightly illuminated with a good light. If the mucous membrane be not too firmly adherent, it should be dissected back, to be replaced after the operation. The end of the nose is turned upward and backward, and held with a retractor by an assistant; then enough of the superfluous tissue is removed or dissected out to allow the nose to conform to the desired shape. Great care must be exercised, however, not to remove too much tissue, and also not to cut through into the skin, lest a scar or indentation in the external surface of the nose be produced. In some cases no after-treatment is required; in others it is desirable to mould a saddle or splint, as it were, to the top of the nose, so that it shall in healing retain the proper contour.

In some cases the large and unsightly end of the nose is not due to an excess of tissue, but to a malformation of the cartilages of the alæ, which bulge markedly upward, with a corresponding concavity inside. Such noses can readily be moulded into a handsome shape by cutting, with a small tenotomy-knife, through the car-

tilages in different places, sufficiently to destroy their elasticity; then a silver tube of the proper size and shape is inserted into the nostril, and the saddle is adapted to the outside of the nose, so that the organ is thus embraced between an inside and an outside splint, which compel it to assume the exact shape required.

In performing these operations it is necessary to remember that the nasal passages must be kept free and unobstructed.

Hæmorrhage during and after any of the operations mentioned is generally severe. It may be lessened, however, through the depletory effect of cocaine, and still more satisfactorily by the direct application of hot water. In the course of the operation it is well, on the whole, not to attempt to plug the posterior nares, but, by allowing the blood to gravitate into the pharynx, to thus keep the nasal passages free and unobstructed for the entrance of light and the manipulation of the operator. The bleeding is somewhat apt to recur; and instances in which a patient has had to seek professional aid for epistaxis, several hours after the operation, are by no means uncommon.

In conclusion, it will appear that deformities of the nose in general, and of the nasal septum in particular, have of late received unusual attention. This attention, moreover, has been rewarded by large accessions of knowledge as to their anatomy, causation, and general results; and their presence has been met by a constantly increasing series of ideas and methods directed to their relief. Already many of them are amenable to the means now known, and it is not impossible that the near future may bring other and more improved operations for the cases still difficult to reach. It may safely be urged that the day of severe surgical procedures, involving incision and disfigurement of the external surface of the face, has gone by. Even Rouge's operation (see article Nose, Tumors of) can only be justifiable in cases where there is extreme difficulty in reaching the nasal fossæ through the natural passages, while with accurate knowledge of the part to be operated upon, and trained skill and experience in operating, few cases will present themselves, in which, by comparatively simple means, the best work cannot be done and the best results secured. These acquirements, however, are absolutely essential to safe and successful operation, since there is no part of the body where greater injury can be done by the rash, the unscientific, or the ignorant. Above all, a thorough acquaintance with the anatomy and pathology of the bony structures of the nose is of the utmost importance.

D. Bryson Delavan.

NOSE: HÆMORRHAGE FROM THE NASAL PASSAGES. The term epistaxis (ἐπὶ and στάζω) was used by the ancients in an extended sense to denote bleeding from the nose in general, whether it proceeded from lesions of its external or internal surface, but its use has been restricted by modern authors to those hæmorrhages which take place from the nasal and accessory cavities.

The great vascularity of the mucous membrane of the nasal passages, its spongy or cavernous structure, the intimate connection of its blood-vessels with those of adjacent organs, and their corelation with other vascular tracts in remote portions of the body; its constant exposure to the exciting causes of hyperæmia, together with a certain amount of vulnerability begotten of its natural delicacy of structure, combine to make epistaxis the most common of the hæmorrhages of man.*

Hæmorrhage from the nostrils may be active or passive; may be the result of traumatic causes, symptomatic of various intrinsic pathological conditions, or occur as a critical or vicarious phenomenon.

Traumatic epistaxis follows contusions, fractures, and other surgical injuries of the nose, or occurs as the result of mechanical irritation of its interior from scratching, rubbing, or picking with the finger; from instrumental interference within, or the application of caustic medicaments to, the nasal fossæ or nasal pharynx; from rupture of varicose veins in the latter situation; from overfilling of the capillaries due to overaction of the heart, as, for example, in diseased conditions of that organ, or due to severe exercise, as in the general vascular agitation of the body which accompanies violent expiratory efforts, such as coughing, sneezing, vomiting, and the like, or dancing (Alibert), and coitus;* from the corrosion of the membrane produced by the inhalation of irritating vapors and powders (bichromate of potash, iodine, chlorine, ipecac, veratrum, chloroform, etc.), or from poisonous doses of those drugs that are eliminated through the mucous surface of the upper respiratory tract; from the solution of continuity of structure, occasioned by ulceration of various kinds, the separation of crusts, the presence of tumors (notably carcinoma and sarcoma); from foreign bodies, insects, and parasites in the nasal and accessory cavities. Under this head, too, may be included the hæmorrhage from the nostrils which occurs in certain surgical injuries of the skull, and particularly fracture of the base, and those affections of the nasal passages accompanied by caries or necrosis. It may also result from concussion. In the famous naval combat between the Merrimac and Monitor, during the civil war, blood spouted from the nostrils of the crew of the former when the round top was struck by the hostile iron-clad.

When slight traumatic causes give rise to nasal hæmorrhage, the explanation is almost always to be found in some local or constitutional predisposing condition, such as a pre-existing catarrhal affection, the previous tendency to epistaxis, the sanguine temperament, or disturbances in the vascular system induced by a host of debilitating influences, such as luxurious living, and excesses of all kinds (over-indulgence in alcohol, tobacco, venery, etc.), the presence of a diathesis, as the hæmorrhagic, scorbutic, etc., and possibly from some imperfectly understood inherited or acquired proclivity, or vaso-motor neurosis. In such persons, over-exertion of the mental faculties, anxiety, violent emotions, and even forcing the voice in declamation and singing, are sufficient to induce copious hæmorrhage from the nose.

Anything that tends to produce an increased flow of blood to the nose, or to delay or obstruct its return to the heart, that increases vascular tension or lessens the resistance of the vessel-walls, predisposes to, and may be the exciting cause of, nasal hæmorrhage. Thus, epistaxis is common in the plethoric, in those addicted to the use of stimulants, and in the so-called apoplectic, and is the crowning symptom of the group of phenomena referable to general excitation of the vascular system, known under the technical name of the nixus hæmorrhagicus. It is also often met with as the result of passive venous hyperæmia from organic disease of the heart, lungs, pleura, kidneys, etc.; from pressure on the venous trunks of the neck, thorax, and abdomen (tumors, dropsy, tight clothing, etc.); in various congestive conditions of the brain, meninges, and cerebral sinuses. It is not infrequently the forerunner of extravasation of blood into the brain-substance, and of retinal apoplexy in connection with renal affections.[1] It is also predisposed to by habitual interference with the bodily excretions, notably the intestinal. It is a familiar accident in the rapid passage from a dense to a rarefied atmosphere in balloon and mountain ascensions, where it is due to the diminution in the atmospheric pressure and the consequent determination of blood to the mucous membrane of the air-passages.

Epistaxis occurs as a symptom of a number of acute febrile diseases, in some of which, as, for example, typhoid fever, it is considered as a diagnostic sign. It is also a frequent accompaniment of the hæmorrhagic diathesis, scurvy, purpura, and allied affections; in impoverishment of the blood from other causes, as in chlorosis, leucocythæmia, syphilis, tuberculosis, malarial fevers, etc.; in congestion and other diseases of the liver and spleen.†

* It was the opinion of Pliny (Nat. Hist., lib. xi., cap. 91) that "man is the only creature from whom blood flows at the nostrils."

* On the other hand, absolute continence is said to produce it occasionally (Cloquet, Osphrésiologie, p. 554, Paris, 1821).

† The hæmorrhage which takes place in hepatic disease was said to proceed from the right nostril (Galen, de crisibus, lib. iii., cap 3); that from splenic affections, from the left.

It sometimes occurs from the suppression of a cutaneous eruption, from the sudden cessation of a normal flow, as the menses, perspiration, urine, etc., or of a pathological discharge, as in the disappearance of a hæmorrhoidal flux. Fabricius of Hilden,[2] relates a case where it followed the stoppage of hæmorrhage from varicose veins in the leg.

It occurs in boys at or near the age of puberty in whom a predisposition to hæmorrhage in general exists, and in women as the vicarious representative of menstruation. In the latter case, it may establish the menstrual function, the nasal hæmorrhage being replaced subsequently by the uterine flow, or it may continue throughout the menstrual life of the individual, in which case some derangement or malformation of the sexual organs seems to be responsible for the nasal flow.* Vicarious nasal menstruation was considered a favorable sign by Hippocrates,[3] and by Celsus,[4] who followed closely in his footsteps. In sudden suppression of the menses, the nasal hæmorrhage may terminate in death, as happened in a case reported by Alibert.[5]

Hæmorrhage from the nose is met with also during pregnancy, and may be due to vicarious action, or to the pressure of the enlarged uterus upon the abdominal veins. It occasionally occurs toward the close of menstrual life, and has been observed as a recurring phenomena after removal of the uterus and its appendages by the Porro operation.[6] It may, furthermore, be symptomatic of reflected irritation from the gastro-intestinal (piles, worms in the intestines) and genito-urinary tracts, and in children, from diseases of the gums or eruption of the teeth.

The sudden impressions made upon the cutaneous surface in its entirety, or upon its individual parts, such as the feet, neck, hands, scrotum, etc., of extremes of heat and cold, as in sudden exposures to temperature variations, hot and cold baths, etc., are sometimes sufficient to induce copious hæmorrhage from the nose.†

In some instances the bleeding seems to arise from psychical impressions, conveyed through the sense of smell, from various articles of food,[7] such as cheese, apples, the odor of the rose, etc., from the pollen of certain plants, or from the presence of minute forms of animal life in the atmosphere, and this perverted sense seems to be peculiar to certain families. It is highly probable that this so-called "idiosyncrasy" is explicable on the hypothesis of coincident local nasal disease, or of some functional vasomotor neurosis. Blancard[8] relates a case where the ringing of bells always produced epistaxis. In this connection may be mentioned the case recorded by Salmuth,[9] where a young man was habitually so affected by the sight of a hæmorrhage from his mistress' nose, that blood began to flow immediately from his own, and a similar observation is related by Rhodius.[10]

Now and then, epistaxis is encountered as an intermittent or periodical condition occurring at regular intervals (Taunton[11]), and depending in some instances on a malarial cause, as evidenced by its disappearance on the exhibition of quinine (Millet[12]).

The so-called epidemic occurrence of epistaxis is probably explicable by the prevalence of some malignant systemic disease with prominent local complications, or by the existence of meteorological conditions favorable to congestive states of the nasal mucous membrane.

Hæmorrhage from the nose is a not uncommon symptom of nasal catarrh. It may be small in amount, or be sufficiently copious to produce considerable depression, and even collapse. It is generally excited by picking, scratching, rubbing, or blowing the nose, by sneezing and coughing, by the separation of crusts, and a multitude of other exciting causes that determine an increased flow of blood to the nasal membrane. Sometimes such hæmorrhages occur at night, from unconscious irritation of the nose with the finger during sleep. Quite extensive loss of blood occurs, however, without the intervention of traumatic influences in chronic inflammatory conditions of the nasal tissues, perhaps from congestion of the cavernous structure and loss of resistance in the erectile cellular walls, or from stoppage of the nostrils,* for when the nose is freed of mucus and crusts, or when the redundant tissue is removed and the normal aerial pathway is restored, the recurring hæmorrhages cease. The bleeding in many such cases comes from the cavernous tissue. Indeed, nasal obstruction from any cause (deflection of the septum, hypertrophic enlargements of the nasal structures, etc.), predisposes to epistaxis, in all probability from the creation of a more or less complete vacuum behind the seat of obstruction. The writer has seen very alarming hæmorrhage occur from such a condition, the blood flowing into the stomach and air passages and leading to the suspicion of pulmonary disease. This is probably also the explanation of many cases of so-called "spontaneous" epistaxis. The same is also true in regard to obstruction in the retro-nasal space, closure of the posterior nares *plus* the consequent congestion of the nasal passages, and the altered relations in regard to atmospheric pressure conditioning the predisposition to hæmorrhage. In cases, moreover, wherein no bleeding-point is discoverable in the nasal passages, it must be remembered that the flow may come from one of the accessory sinuses, or even from the middle ear.

Epistaxis is, perhaps, most commonly met with in infancy, is less common in youth and manhood, while in later life, the tendency to hæmorrhage reappears, a fact to be explained by the degenerative changes in the vascular system which accompany the processes of old age.

The symptoms of rhinorrhagia do not differ from those of hæmorrhage in general. Usually the amount lost is small and insufficient to give rise to constitutional disturbance. It escapes drop by drop from the nose, or it may flow in a continuous stream. The literature of the last two centuries contains accounts of cases where large quantities of blood were lost in a short while, and if we can believe the reporter,[14] as much as seventy-five pounds has been known to escape in the space of ten days. Those who suffer from habitual epistaxis are subject to derangements of vision.

The bleeding generally comes from one nostril, but may occur from both. When the bleeding-point is seated anteriorly, the blood flows from the anterior naris, while, if it is located in the posterior portion of the nostril, the blood escapes into the throat, aided in its passage to that region by the natural obliquity of the nasal floor. Gaining the throat, it is either expectorated or enters the air-passages, and is removed by coughing; or it may gravitate into the œsophagus and be swallowed. Its presence in the stomach may excite vomiting, or it may pass through the alimentary canal and be voided at stool. Finally, the blood may be discharged through the lachrymal ducts and puncta.

Pathological Anatomy.—The hæmorrhage may take place from the surface of the mucous membrane, or into the submucous tissues. The latter generally occurs in connection with blood-poisoning or traumatism. Bloody tumors (hæmatomata) of the nasal fossæ, especially of the septum, are occasionally encountered as the result of mechanical injury.[15]

The writer has observed, on microscopic examination, quite extensive hæmorrhages into the cavernous tissue in long-standing cases of hypertrophic catarrh. The extravasation may take place into the meshes of the cavernous body, or between it and the mucous membrane. When the bleeding has been slight, the only macroscopical evidence of its existence will consist in minute extravasations (ecchymoses) or capillary apoplexies. Usually the nasal mucous membrane is intensely hyperæmic. The hæmorrhage generally arises from solution of continuity of the membrane at isolated spots or over circumscribed areas, rarely, if ever, from the whole surface of the nasal fossa. The point of origin of traumatic epistaxis will obviously depend upon the nature and mode of operation of the mechanical or chemical irritant, or upon the situation of the lesion which produces it.

In view of the intimate vascular communication be-

* A case of this kind has come under the observation of the writer.

† According to Cloquet (op. cit., p. 554) there are certain springs in Auvergne the temperature of whose waters is so low that copious hæmorrhage from the nostrils occurs from immersion of the hands during the heated term

tween the erectile tissue and the cerebral circulation, it is highly probable that the so-called "critical" hæmorrhages and those by which congestive conditions of the brain are relieved, and perhaps also those of vicarious origin, take place from the cavernous bodies, which latter may be looked upon, therefore, among other physiological properties which they possess, as serving, in that respect, a certain teleological purpose. Whether this be true or not, the writer is convinced that many nasal hæmorrhages originate primarily from the vascular spaces of these bodies, and that the latter play an important rôle in the pathology of epistaxis.

The bleeding-point is very frequently found upon some portion of the cartilaginous septum. As Valsalva pointed out long ago,[16] it frequently occurs at the junction of the "alæ nasi with the bone, about a finger's-breadth, more or less, from the bottom of the nostrils."

The respiratory region, being more exposed to the exciting causes, is consequently more often the seat of hæmorrhage than the olfactory portion of the nose.

On microscopic examination, various changes are found in the vascular walls, such as degenerative appearances from atheroma, syphilis, softening, sloughing, and rupture of the vessels, etc. Extreme tenuity of the fibrous trabeculæ of the cavernous tissue is also occasionally met with.

Diagnosis.—Hæmorrhage from the posterior nares may be confounded with hæmoptysis, hæmatemesis, or bleeding from the bowels (*vid. supra*), an error which may generally be avoided by examination of the nostrils, when some evidences of its occurrence will be found. In fevers, care should be taken to discriminate between a critical hæmorrhage and that which results from a serious nasal complication, the former being a favorable sign, the latter one of grave moment, and calling for prompt attention. Finally, the possibility of its origin from the accessory sinuses, the middle ear, and even from the cerebral vessels,[17] should not be overlooked, and, on the other hand, the possibility of simulation for purposes of malingering should be borne in mind.

The Prognosis depends upon the cause of the hæmorrhage. In the majority of instances it is good. Critical and vicarious hæmorrhages which serve to relieve congestive conditions of neighboring or remote organs, or to complicate local disease of a curable nature, afford also a favorable prognosis. When, however, the bleeding is dependent upon a diathesis, or occurs as the complication of serious structural disease from acute blood-infection, especially in the course of certain epidemic influences, or of organic visceral changes, the result is less favorable. Collapse may occur from the loss of large quantities of blood, or the constant losses of small quantities may beget an impoverished condition of the system, with derangement of nutrition, and an enfeebled state of the special senses, and may even awaken the predisposition to more serious organic disease.

Treatment.—When one is called to a case of epistaxis, the first thing to determine is its nature. Vicarious and critical hæmorrhages should be left to nature unless the flow be so excessive as to jeopardize the life of the patient. Slight bleeding from the nose, of whatever nature, may also be disregarded, as the tendency is to spontaneous arrest.

The measures usually employed for the stoppage of more profuse nasal hæmorrhage may be conveniently considered under the following heads: (1) rest; (2) position; (3) revulsives, and measures designed to produce reflex contraction of the nasal blood-vessels; (4) opiates and narcotics; (5) astringents; (6) remedies to slow the action of the heart; (7) caustic applications to the bleeding-points; (8) pressure, external and internal; (9) transfusion.

In moderately severe cases of epistaxis, the patient should remain perfectly quiet in the sitting position, with the head inclined very slightly downward and forward, to throw the floor of the nostrils into a perfectly horizontal plane. All tight clothing about the neck and thorax should be loosened, and the sufferer should be directed to avoid, if possible, all tendency to sneeze or cough, and all downward or backward movements of the head. Respiration may be carried on through the mouth. The fears of the patient should be quieted; in nervous people, the very sight of the blood often serves to increase the hæmorrhage. Great weakness or tendency to vertigo may require that the patient be placed in the recumbent position, or he may be propped up in bed with pillows in the semi-horizontal decubitus. Holding both arms above the head, throwing, suddenly, the arm corresponding to the affected nostril vertically upward, and compressing the bleeding naris with the fingers of the opposite hand (Négrier[18]), pressure at the root of the nose, above the upper lip, or on the corresponding facial or carotid artery, and similar devices, have been from time to time recommended and employed.

Measures applied to excite reflex contraction of the blood-vessels in the nasal mucous membrane are often of service; such are the application of cold to the nape of the neck (cilio-spinal centre), to the hands, feet, breast, scrotum, rectum (ice clyster of Sydenham), or forehead, dashing cold water in the face, or on the back, etc., or various revulsives applied to these regions. A method in use among the ancient Greek and Arabian physicians consisted in opening a vein in the foot. The Greeks used cupping-glasses to the hypochondrium, and local depletion for the nostril from which the blood flowed. In the Middle Ages, a favorite method was to apply the actual cautery to the soles of the feet, and several centuries ago it was recommended to bend the little finger on the bleeding side backward, which procedure, it was thought, acted as a revulsive by the great pain which it produced, and the consequent determination of blood to the part. Cupping the blood in the extremities is also an old practice, which led to the famous Jounod's hæmostatic boot. It is highly probable that the old-fashioned method of venesection from the arm did more good by the subsequent compression of the bandage and the retention of blood in the forearm than by the way in which it was alleged to act.

In some cases the flow of blood may be arrested by opiates and narcotics. Of these, the most serviceable is morphine given hypodermatically.

The principal astringents employed for the relief of nasal hæmorrhage are hot and cold water, alcohol, perchloride of iron in solution or crystalline form, alum, chloride of zinc, ammonio-ferric alum, tannic and gallic acids in powder or suspension, kino, and catechu; the internal administration of turpentine, the mineral acids, etc., and the hypodermatic use of ergot and morphine are recommended. Hot water and alcohol are especially efficacious. Great caution should be exercised in the use of the perchloride of iron, for it not only often fails to arrest the hæmorrhage, but also gives rise to a dirty mass in the nostril, which may even, through decomposition, excite septicæmia. A case is on record in which the injection of perchloride of iron led to pharyngo-bronchitis, and death from gangrene of the lungs. The introduction of cobwebs into the nostril will often suffice, by acting as a styptic, and at the same time allowing coagulation of blood in its meshes, to arrest the hæmorrhage.

Astringents can also be employed on tents, as originally recommended by Valsalva and Morgagni, or by means of soluble bougies.

In severe cases it is sometimes of service to slow the action of the heart with digitalis and similar drugs.

The ancient custom of introducing wicks, and strips of various substances, for the purpose of promoting coagulation, is, as a rule, successful, or a feather or similar object may be used for the same purpose.

If a bleeding point can be discovered, it is usually sufficient to apply some caustic, such as chromic acid, to prevent recurrence of the hæmorrhage; or the same end may be attained by the electric, or even the actual, cautery.

By means of the above measures, the necessity for tamponing the nares may generally be obviated.

If the hæmorrhage be at all alarming, plugging the nostril should be at once resorted to, as it is useless to temporize with less radical measures. Of all methods of

arresting hæmorrhage the best is pressure. This may be accomplished by simply pressing the ala against the septum and the opening of the nasal fossæ, or by the introduction of the finger within the nostril and making direct pressure on the bleeding point, or by tamponing the vestibule and anterior portion of the fossa with absorbent cotton, sponge, charpie, strips of lint, oakum, etc. If the hæmorrhage arise from the posterior portion of the nostril or nasal pharynx, resort must be had to plugging the posterior nares. For this purpose a number of measures have been devised, the most familiar of which is the cannula of Bellocq, an instrument perhaps more often figured and less frequently used than any other in the armamentarium of the surgeon (see Fig. 2512). As a substitute for Bellocq's instrument, an ordinary soft-rubber female catheter or hollow œsophageal bougie, or a large-sized Eustachian catheter, may be employed. A rubber, catgut, or silk string is passed through the lumen of the instrument, which latter is then introduced through the nasal passage into the pharynx. The distal end of the string is then caught with a pair of forceps or other convenient apparatus, and drawn out of the mouth. The sponge, or whatever material be used, is then tied securely to the string, and traction is made on its proximal end until it is securely impacted in the posterior nares. Instead of using cotton, etc., in plugging both anteriorly and posteriorly, resort may be had to various substances, such as different kinds of rubber bags, a piece of the intestine of an animal, closed at one end, introduced on a probe into the nostril and then inflated with air or water. Even a condom may be used for this purpose. Various kinds of apparatus, modelled on this principle, are to be had in the market, and go under the euphonious names of "rhinecurynters" and "rhinobyons."

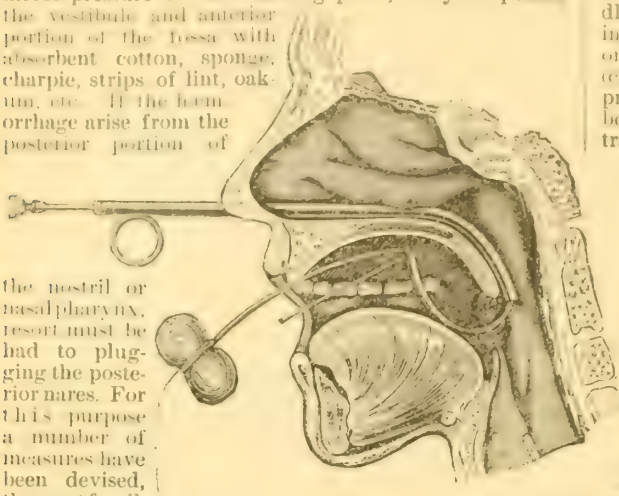


Fig. 2512.—Plugging the Posterior Nares by Means of Bellocq's Sound.

While plugging the nostrils is the most efficacious method of stopping hæmorrhage from the nose, it is not altogether devoid of danger. If the plugs be left in too long, septicæmia, erysipelas, suppurative otitis (Gellé [19]), and even gangrene of the face (Créquy [20]) may possibly complicate the case. I have also seen unilateral convulsions of the muscles of the face, neck, and extremities follow the retention of a plug in the nostril, and immediately subside on its removal. Care should always be taken to affix a string securely to the plug, in order to insure removal and prevent gravitation into the throat. In a case under the care of Dr. Oscar Coskery, of Baltimore, in which the patient himself had tamponed his own nares, the plug was loosened during sleep, and becoming impacted in the larynx, caused death by suffocation.

Posterior plugging is, furthermore, occasionally open to an additional danger from tetanus. Such a case has come under my notice, occurring in the practice of a well-known physician of this city, and another in the experience of Dr. Colles, of Dublin, is frequently referred to by writers on epistaxis.

After the plugs have been taken out (which should be done, if possible, within twenty-four hours), careful search should be made for the source of the hæmorrhage. Apart from well-defined lesions in the nose, it will be not infrequently discovered that the hæmorrhages come from little spots or areas, which will generally be found either on the septum, just within the vestibule, or on the middle and lower turbinated bodies. These turgid or bleeding areas should be touched with the galvano-cautery or with chromic or acetic acid. When great turgidity (chronic puffiness) of the turbinated bodies is present, producing obstruction of the nostril, a stellate cut may be made into them with the cautery knife. In the contraction of the tissues which ensues, the nostril becomes free, and the hæmorrhages usually cease.

The internal treatment of epistaxis does not differ from that of hæmorrhages in general. Syncope demands stimulation, general prostration tonics, and even transfusion may be resorted to with success in extreme cases. In examples of the "hæmorrhagic diathesis" the bleeding may continue in spite of plugging, until it stops through heart failure.

John Noland Mackenzie.

[1] Hughlings-Jackson: London Hosp. Clin. Lect. and Reports, vol. iii., p. 251. S. Watson: Dis. of the Nose, etc., Lond., 1875, p. 51.
[2] Cited by Friedreich: Virchow's Handb. d. Path. u. Ther., 1855, Bd. V., 1 Abth., s. 389.
[3] Op. omnia. Ed. Kuhn., Lips., 1827, tom. iii., p. 174. De morbis, lib. i., and Aph., Sect. 5, Art. 33.
[4] De medicinâ, lib. i., Cap. 8.
[5] Nosologie naturelle, etc. Paris and Lond., 1858, p. 557.
[6] Arch. de Toxicologie, April, 1884. Am. J. Med. Sc., July, 1884, p. 292.
[7] Bruyerus: De re Obstetr., lib. i., Cap. 24.
[8] Collect. Med. Phys., Cent. VI., Obs. 74.
[9] Obs. Med., Brunswick, 1648, Cent. I.
[10] Cent. I., Obs. 89 (cited by Good, Study of Medicine, Phila., 1824, vol. ii., p. 460).
[11] Lond. Med. and Surg. Journal, 1830, vol. iv., p. 489.
[12] Journal de Connais. Med. Chir., Août, 1841 (Friedreich, op. cit., s. 388).
[13] See paper by author in Trans. Med. Chir. Fac. of Maryland, 1883, on Naso-Aural Catarrh and its Rational Treatment.
[14] Act. erudit. Lips., 1698, p. 265.
[15] Flemming: Dublin Journ. Med. Sci., 1883, vol. iv.; also, Jarjavay (cited by Beaussenat, Des tumeurs sanguines et purulentes de la cloison des fosses nasales, Thèse de Paris, 1864).
[16] Morgagni: De sedibus et causis morborum, tom. i., xiv., 24, ii., fin.
[17] See case of Koppe, Arch. f. Ohrenheilkunde, Bd. ii., S. 181 (Fraenkel, Ziemssen's Cyc., Am. ed., 1876, vol. iv., p. 159).
[18] Archives générales de médecine, vol. xiv., p. 168, 1842.
[19] Rev. mens. de laryng., vol. vii., No. 12.
[20] Gaz. des Hôp., 1870, vol. lvi.

NOSE, NEUROSES OF THE. I. The Physiological Nasal Reflexes.—Before passing to the discussion of the essentially neurotic conditions of the nose, it will be necessary to consider two acts or phenomena which are intimately related to the physiology of the nasal apparatus, and which may be regarded as the normal nasal reflexes, viz.: *Sternutation*, or *sneezing*, and *nasal cough*. To these may be added still another, which partakes of the characters of both sneezing and coughing, which seems to be the resultant of an attempt at the simultaneous accomplishment of both acts, and which, for want of a better name, may be denominated *sneeze-cough*.

Sneezing is the natural method by which the nasal apparatus resents direct or indirect injury to its interior—the normal protective reflex. It is only when it is repeated sufficiently often to cause inconvenience, or occurs in well-marked paroxysms, that it may be looked upon as a pathological phenomenon. In this latter aspect it will be considered farther on in this article.

Nasal Cough.—In 1883* I first called attention to cough as a physiological nasal reflex, and to the frequency with which, in an aggravated form, it is met with as a symptom of nasal disease. Like sneezing, it may be looked upon as a normal protective act. As a pathological phenomenon it will be fully discussed in the section which treats of the Neuroses Proper.

My attention was first directed to the study of nose-cough by the repeated observation that, during manipulation with instruments (probe, forceps, snare, Eusta-

* On Nasal Cough and the Existence of a Sensitive Reflex Area in the Nose. American Journal of the Med. Sciences, July, 1883. The results of these experiments were first brought before the Baltimore Medical Association in the early part of 1882, and subsequently before the Medico-Chirurgical Faculty of Maryland (April, 1883, *vide* Transactions) and the American Laryngological Association (May, 1883, *vide* Transactions).

chian catheter, etc.) within the nasal fossæ, paroxysms of coughing were induced, which only subsided upon the withdrawal of the instrument, or upon changing its position in the nasal chamber. The cough varied greatly in character, from a succession of short expiratory acts to convulsive paroxysms which interfered seriously with the use of the instruments. These attacks occurred, furthermore, only when the foreign body came in contact with the deeper portions of the nostril; in several cases where the snare was used, they seemed to be excited only at one particular spot in its passage through the nose, and ceased when the loop entered the naso-pharynx. My clinical experience, too, furnished me with cases where distressing cough existed, the etiology of which was rendered obscure by the absence of disease or irritation in pharynx, windpipe, or lungs. In this latter case, one of two conditions was invariably present—viz., either a hyperæmic or slightly swollen state of the mucous membrane, chiefly affecting the turbinated bodies, or pronounced hypertrophic enlargement of these structures.

It was in the clinical study of this reflex cough that I was led to assume the existence of a certain area or areas in the nose, the irritation of which would culminate in a reflex act or in a series of reflected phenomena. The existence of such an area had been demonstrated in the larynx and trachea, and it seemed, therefore, legitimate to assume the presence of similar spots in the nasal chamber. The well-known occurrence of reflex asthmatic attacks in some cases of nasal polypus, and their absence in others, together with similar observations which I had made in regard to hypertrophic nasal catarrh, lent further support to the hypothesis of a reflex area.

In order, if possible, to throw some light upon this subject, I made a series of experiments upon a large number of hospital patients, upon myself, and upon several of my medical friends who were kind enough to place their nasal organs at the disposal of science. The experiments consisted essentially in the systematic irritation of all accessible portions of the nasal mucous membrane, the irritants used being silver and rubber probes and the steel wire, such as is used in the polyp-snare.

It may be here remarked that the nose of the negro is admirably adapted for experiment, on account of the great capacity of the nasal chambers anteriorly, rendering dilatation by artificial means unnecessary, and hence eliminating a source of error which might vitiate the result of the experiment. The great width of the vestibule, too, brings into greater prominence the anterior ends of the turbinated bones, or, rather, their mucous covering, which, in the black race, is much more puffy anteriorly than in the white man, giving the appearance of what in the latter would be taken for an anterior hypertrophy. It is also very flabby, collapses under the probe, and can be pressed with ease against the external wall of the nostril.

The patients experimented on presented varying degrees of susceptibility to irritation; in some instances, the slightest touch was sufficient to provoke the reflex act, while in others it was only excited by repeated irritation or long-continued pressure. In some cases no reflex whatever could be obtained. The results of these experiments may be briefly given as follows:

So long as the stimulation was confined to the vestibule—to the interior of the fleshy, cartilaginous part of the nose—the result was negative; no reflex action was obtained. The sensation created was simply that of a foreign body, or, if the stimulus was increased, a feeling of pain. So far I have been unable to excite cough by stimulation of this part of the nose. Irritation of the membrane clothing the anterior extremities of the middle and inferior turbinated bones was in some instances negative; in others a half-tendency to cough was produced, which increased as the irritant was applied farther back, and finally culminated in the act when it was directed upon the posterior half of the turbinated body. Irritation of the floor of the nose was negative in result. In cases where stimulation of the remaining portions of the nose failed to excite them, paroxysms of cough were induced when the irritant was applied to the mucous membrane covering both the inferior and middle turbinated bones; but the act was most constantly obtained from the posterior end of the inferior turbinated bone and the portion of the septum immediately opposite. Indeed, my experiments seem, thus far, to show that these portions are the most sensitive spots in the reflex area. In passing along the pars nasalis of the roof, coughing was occasionally produced when the probe or wire impinged on the anterior extremity of the middle turbinated bone; but no decided results could be obtained from the upper olfactory region.

We have thus experimental proof that all parts of the nasal mucous membrane are not equally susceptible to the impression by which reflex cough is produced, and, furthermore, that the cough or reflex area is probably limited to the mucous membrane covering the middle and inferior turbinated bodies and the posterior half of the septum. Now, this is the area occupied by the erectile tissue of the nose, and it is hard to resist the conclusion that this structure is in some way connected with the evolution of the reflex act, and that the peculiar susceptibility to irritation is to a great extent intimately associated with its physiological functions, whatever they may be.

Roughly speaking, the greater the congestion, or inflammation, the more constant the reflex obtained. I have succeeded, however, in producing violent paroxysms of laryngeal cough by simply touching, with the aid of the rhinoscope, the posterior extremity of the inferior turbinated bone in persons whose noses were free from disease. In some cases, stoppage of the nostril with discharge of mucus was produced, while in others this was not observed.

That the sensitive area is principally confined to the parts already indicated—viz., the posterior half of the inferior turbinated body and septum—is furthermore rendered exceedingly probable by the following clinical facts:

(1) That in cases where reflex cough exists, these are the portions chiefly, if not solely, involved.

(2) That the act may be produced here at will by artificial stimulation of the parts invaded by the morbid process.

(3) That it may be dissipated by local applications to, or removal of, the membrane covering the diseased surface.

(4) That foreign bodies, such as pins, lodging in this area sometimes give rise to cough, which latter is not observed when they become impacted in other portions of the nose.

(5) That polypi give rise to reflex phenomena only when they arise from, or impinge upon, the sensitive portions of the area.

(6) That where complete atrophy of the turbinated structures exists, as, for example, in ozæna, reflex cough is not present, nor can it be induced by artificial stimulation.

These facts are the outcome of personal experience; and, as they represent the result of solitary observation, are, of course, open to correction. I have never seen, nor do I know of, a single case where a foreign substance impacted in the non-sensitive portions of the nose has given rise to cough; but I do know of cases where that act was excited by its presence in the reflex area. In regard to *reflex asthma* from polypi, the literature accessible to me shows that, where the position of the tumor is accurately defined by the reporter, it is always in the posterior portions of the nostril, in a situation which would lead to irritation of the sensitive tract.

So far as my experience goes, it would appear that the cough is present only when the growths spring from or are brought in contact, in some way or other, with a portion of the erectile area, and generally its posterior portion. Or, in other words, it is only when the polypus acts as a mechanical irritant by causing irritation of the mucous membrane, and thereby exciting reflex action, that the explosive cough is produced. The probability, therefore, of cough-excitation will depend, other things being equal, upon the position of the growth. Thus, for

example, a polypus situated high up in the nostril may fail to give rise to the reflex act which its presence lower down in the nasal fossa would excite. Or a movable growth in the more anterior portion of the nasal chamber may awaken no reflex when the head is in the vertical position, while when the vertical diameter of the nostril becomes horizontal, as, for instance, in the recumbent position, the growth may by force of gravity be brought in contact with the posterior portion of the nostril or, what is the same thing, with the most excitable spot in the sensitive area. In the same way the asthmatic attacks, which have been observed in connection with nasal polypi, may be explained. At all events, such an explanation is more plausible than the assumption, which may be urged, of direct nervous irritation starting from the polypus itself; since the ordinary mucous polyp is destitute of nerves, and can, therefore, only awaken reflex phenomena in an indirect or mechanical manner. Moreover, I have tried to obtain the reflex by direct stimulation of the growth, but so far without success. Finally, I wish to observe that the change in position of the polypus does not depend altogether upon the law of gravitation, but in some instances may be due to an increase in volume, either from local irritation of various kinds or from the well-known hygroscopic character of the gelatinoid outgrowth. The augmentation in bulk thus brought about would obviously bring it into contact with parts which in its original position would not be encroached upon, and therefore not subjected to the pressure and irritation which it might occasion.

Nasal cough has become so common in my experience, that I have long since ceased to regard it as a curiosity. It is worthy of remark that in a fair proportion of cases there are few, if any, symptoms which would direct attention to disease of the nose; and this fact emphasizes the importance of examining the nasal chambers in all cases of the kind, even though the testimony of the patient may lead to neglect of their systematic exploration.

My clinical observation leads me to the belief that reflected irritation from nasal disease plays a not inconspicuous part in the etiology of laryngeal congestion and inflammation. The short, hacking cough and hyperæmia of the larynx which occur in acute coryza are probably more often explicable on the theory of reflex action than upon the extension of the inflammation to the laryngeal vestibule. The physiological explanation of this phenomenon may possibly be found in the doctrine of correlated areas, the reflex taking place through the vaso-dilator nerves from the superior cervical ganglion of the sympathetic. In chronic coryza, on the other hand, the constant laryngeal hyperæmia induced by reflex nasal irritation, augmented, perhaps, by the frequent occurrence of cough-paroxysms, may, if prolonged, eventuate in catarrhal conditions of that organ. In other words, on theoretical grounds, and clinical observation would seem to sustain them, it is legitimate to assume the existence of a *reflex laryngitis*, evoked through the constant irritation of the vaso-motor centres from chronic nasal inflammation.

Clinical and experimental investigation would appear, then, to lead to the following conclusions:

(1) That in the nose there exists a definite, well-defined, sensitive area, whose stimulation, either through a local pathological process or through the action of an irritant introduced from without, is capable of producing an excitation, which finds its expression in a reflex act or in a series of reflected phenomena.

(2) That this sensitive area corresponds, in all probability, with that portion of the nasal mucous membrane which covers the turbinated corpora cavernosa.

(3) That reflex cough is produced only by stimulation of this area, and is only exceptionally evoked when the irritant is applied to other portions of the nasal mucous membrane.

(4) That all parts of this area are not equally capable of generating the reflex act, the most sensitive spot being probably represented by that portion of the membrane which clothes the posterior extremity of the inferior turbinated body and that of the septum immediately opposite.

(5) That the tendency to reflex action varies in different individuals, and is probably dependent upon the varying degree of excitability of the erectile tissue. In some the slightest touch is sufficient to excite it, in others chronic hyperæmia or hypertrophy of the cavernous bodies seem to evoke it by constant irritation of the reflex centres, as occurs in similar conditions of other erectile organs, as, for example, the clitoris.

(6) That this exaggerated or disordered functional activity of the area may possibly throw some light on the physiological destiny of the erectile bodies. Among other properties which they possess, may they not act as sentinels to guard the lower air-passages and pharynx against the entrance of foreign bodies, noxious exhalations, and other injurious agents to which they might otherwise be exposed?

Apart from their physiological interest, the practical importance of the above facts in a diagnostic and therapeutic point of view is sufficiently obvious. Therein lies the explanation of many obscure cases of cough which heretofore have received no satisfactory solution, and their recognition is the key to their successful treatment.*

In calling attention to this area as containing the spots most sensitive to reflex-producing impressions, I did not, nor do I now (as has been wrongly inferred), desire to maintain that reflexes may not originate from other portions of the nasal mucous membrane. Indeed, wherever there is a terminal nervous filament it *may* be possible to provoke sneezing, lachrymation, and other reflex movements. My contention is simply this, that the area indicated in my original paper represents by far the most sensitive portion of the nasal cavities, and that pathological reflex phenomena are in the large majority of cases related to diseased conditions of some portion of this sensitive area. That all pathological nasal reflexes arise from irritation of this particular area is a proposition which I do not, and never have, maintained. The determination of these sensitive areas is of especial importance and interest in the solution of the pathology of the nasal reflex neuroses. Their location has formed the basis of the modern treatment of these affections.

These views of the *sensitive area* were, at their time of publication, opposed by Dr. Wilhelm Hack,[1] of Freiburg, who, in an exceedingly interesting and instructive brochure, maintained, as the result of his wide experience, that the anterior extremity of the inferior turbinated bone is the point from which all reflexes take their origin, and that those arising from stimulation of other portions of the nostril occur only secondarily, through congestion of the cavernous tissue of this circumscribed locality. In proof

* The above account of nasal cough and the reflex sensitive area is a verbatim abstract taken from my original article in the American Journal of the Medical Sciences. The remarks on the production of reflex cough by change of position in nasal growths are taken verbatim from an article in the Transactions of the Medico Chirurgical Faculty of Maryland for 1884, entitled, "Cases of Reflex Cough due to Nasal Polypi, with Remarks."

At the time of publication of my original thesis I could find only two recorded cases of nasal cough.

Dr. Hack, in the Berliner klinische Wochenschrift, No. 25, 1882, S. 381, relates a case where paroxysms of spasmodic cough, induced by a fibrous polyp which sprang from the right middle turbinated bone, were dissipated by removal of the growth. He regards the case as unique, but adds that, in the course of some physiological experiments on the normal nasal membrane, he had, in a small proportion of cases, noticed convulsive motions of the laryngeal adductors, which sometimes amounted to complete closure of the glottis, followed by an explosive cough-like sound, and suggests that this may also happen under pathological conditions of the nasal membrane.

In the Archives of Laryngology, vol. iii., No. 3, p. 240, 1882, Dr. Seiler reports two cases. In one, severe spasmodic cough, accompanied by a peculiar grunting or barking noise, was dependent upon a deflected septum and a large anterior turbinated hypertrophy; in the other, an excoriation of the mucous membrane of the septum gave rise to reflex cough, which was relieved by treatment of the nasal affection. Dr Seiler observes that he has not found a single instance in which the irritation causing reflex cough was seated in the nasal membrane. He seems, furthermore, to regard the direct irritation of the inter-arytenoid fold (laryngeal-cough centre), by mucus dropping from the post-nasal space, as an important factor in the production of the cough in the two cases described. It is quite certain that cough may be, and is, often produced in the manner suggested; but in that case it obviously cannot be regarded as nasal, i.e., due to an irritation originating in the mucous membrane of the nose.

of his contention he asserts that when the swelling of the anterior end of the turbinated body is present, if the external blade of the speculum be pressed firmly against the swollen turbinated tissues, the remaining portion of the nostril will remain insensible to the reflex-producing impression. In referring to my own conclusions, Dr. Hack suggests that it would be of great value if I should repeat my experiments from the stand-point of his own extensive experience. In a later publication, however, while still decidedly opposed to my doctrine, he has considerably modified his exclusive views upon the subject. He admits that secondary reflexes may take their origin from the middle turbinated bone, especially in the case of migraine, more rarely in that of asthma; he also makes the important admission that in certain cases, after careful extirpation of the swelling at the anterior end, sooner or later a return of the nasal obstruction and the nervous reflex phenomena is observed. In such cases the rhinoscope shows that the parts operated on are represented by a cicatrix so depressed that the parts can scarcely be distinguished, beyond which the cavernous turbinated body is seen, greatly swollen, in the deeper portion of the nostril at such a position that its appearance can only be made out by the most thorough illumination. In regard to the swelling of the posterior end, Dr. Hack observes that, while admitting its possible influence in bringing about the return of the reflex symptoms, his experience compels him to regard this as of infrequent occurrence, having observed only symptoms referable to purely mechanical obstruction, and never reflex phenomena originating in swelling of the posterior area. Hack, then, stands, as he expresses it, in direct opposition to my view, viz., that the posterior end of the inferior turbinated body and posterior half of the septum are the most sensitive spots in the reflex area, and seeks to reconcile the discrepancy in our observations by the supposition of the greater frequency of post-nasal catarrh in America, and the relative infrequency of that affection in Germany, thus affording different conditions for observation and experiment. He furthermore adds, in defence of his own view, that in a number of specimens removed by the galvano-cautery loop from the anterior and posterior extremities of the turbinated bones, and examined microscopically by one of his scholars, the cavernous cells of the anterior portions were very much dilated, and the glandular substance between them was very inconspicuous, while in the posterior portions the cavernous cells were much smaller, and between them the connective tissue was very markedly hypertrophied.

In defending my own position in the matter I wish, at the outset, to distinctly affirm that I do not for one moment call into question the accuracy of Dr. Hack's observations in this direction, which are entitled to the highest respect, and I gladly testify to the pleasure and interest which the perusal of his contributions has afforded me. I simply desire to record my own experience, which, as the result of solitary observation, is open, of course, to correction, and to offer some anatomical grounds for the localization of the most sensitive spots in the reflex area in the lower and posterior portions of the nostrils.

Since I became aware of Dr. Hack's interesting researches, and came into possession of his brochure, in which a repetition of my experiments from the author's stand-point is suggested, I have repeated my observations and put my own views in practice to careful and critical tests. The result has been that I have arrived at essentially the same conclusions as given in my original communication on the subject, viz., that while the reflex may be obtained from any portion of the nasal passages, and especially that portion covered by erectile tissue, the area occupying the posterior and lower portions of the nasal fossæ is that above all others specially concerned in the reflex excitation. Just as in the larynx, while a reflex (*e.g.*, cough) may be obtained from any portion of its internal surface, both clinical and experimental observations have demonstrated that the most sensitive spots are localized in the interarytenoid commissure.

In this country, and I see no reason why the rule should not apply elsewhere, according to my experience, inflammatory conditions of the nasal passages are most marked in the area covered by erectile tissue, and are more pronounced in the lower or respiratory region, in the bony nostril than in the vestibule, and in the posterior more frequently than the anterior portions of the nasal fossæ. The posterior end of the inferior turbinated body is, according to the united testimony of all observers, the most frequent seat of simple catarrhal inflammation and its consequences. Hence this portion of the nostril is the most commonly subjected to pathological irritation—a fact which may explain, in a measure at least, the relative frequency of reflex symptoms arising from this portion of the nostril as compared with those arising from the more anterior parts.

The tendency to sudden filling of the more anterior portions of the erectile tissues, or to permanent enlargement of the same, proceeds generally from two causes: (1) from existing disease of the posterior portion—simple inflammation, hypertrophy, atrophy—in which event it may be regarded, in the majority of instances, as a phenomenon of collateral engorgement; or (2) it occurs in connection with a general engorgement of the cavernous tissue, which may be limited to the respiratory passages, or may extend into the region of olfaction.

It may also be laid down as a rule that changes in the anterior extremity of the turbinated body rarely occur without corresponding, and generally more advanced, disease of the posterior parts of the nasal fossæ—a position which I think will be sustained by my colleagues on this side of the Atlantic; on the other hand, marked changes are frequently met with in the posterior portions of the nasal chambers without corresponding, or even appreciable changes in its more anterior segments. It is, therefore, highly probable, from an anatomical stand-point, that the swelling of the anterior end of the turbinated body occurs through influences which affect, either previously or coincidently, its posterior portion.

Turning now to the anatomy of the turbinated corpora cavernosa, we find that the erectile tissue is most marked and exhibits more strikingly its cavernous nature in the lower and posterior portions of the nostril, and this is notably true of the posterior end of the inferior turbinated body, and the septum immediately opposite. As the more anterior portions of the nostril are reached this tissue becomes less conspicuous, and in the latter situation the mucous membrane is more closely adherent to the underlying tissue, while over the posterior part of the fossa it is loose and separated more completely from the periosteum by the erectile body, which becomes a thin layer as the anterior extremity of the turbinated body is reached. This affinity of the erectile tissue for the posterior portions of the nasal apparatus is strikingly shown in the fact that erectile tissue is found on the posterior ends of all three turbinated bodies. Now the most sensitive zone covers an area which corresponds to the distribution of the spheno-palatine branches of the superior maxillary nerve, as distinguished from the nasal branch of the ophthalmic. The former nerve, derived through the spheno-palatine ganglion, probably contains, therefore, the vaso-motor fibres which govern the erection of the turbinated tissue, and as the sympathetic filaments which have been traced to the nasal passages are found in greater abundance over this area, we may, for practical purposes, speak of a *nasal plexus* located in the sensitive area and intimately associated with the evolution of the nasal reflex. My clinical observation teaches me that this is precisely the area of greatest irritation and turgescence in the paroxysms of vaso-motor coryza and allied affections, and the localization of the sensitive area may be accordingly looked upon as a key to the mechanism of the attack.

I would like also to call attention to a property of erectile tissues which is consonant with the ideas of reflex excitability formulated above. In the human body, wherever erectile tissue is found, it is intimately related to reflex or sympathetic acts; there seems to be connected with it a certain receptivity to reflex-producing impressions, a certain power of reflex excitability depend-

ent upon its structure and functions. It is thus peculiarly a tissue of sympathy, in which we may most satisfactorily study the mechanism of purely reflex or sympathetic acts. Now, as the nasal corpora cavernosa belong to this class of sympathetic tissues, there will be little difficulty in explaining the role which they play in the paroxysms of affections which are probably connected with, if not dependent upon, an excitation of the sympathetic nerve-centres, and in more clearly defining the intimate relation which they bear to the reflex neuroses of the nose.

It seems to me, then, that the above anatomical and physiological considerations strikingly correspond with the results arrived at by clinical observation and actual experiment, and, while open at all times to correction, I cannot but feel that my former observations were at least in the main accurate, and that the most sensitive spot in the reflex zone is represented by the area indicated above.

Sneeze-cough.—I have never seen this condition referred to by writers, but, in my experience, it is of not very infrequent occurrence. It is a most peculiar sound, which, when once heard, is not forgotten, and can be best described, as I have said above, as the result of an attempt to sneeze and cough at the same time. It is neither a cough nor a sneeze, but partakes of the characters of both. In the cases in which I have had an opportunity to examine the nasal cavities and throat, it has apparently resulted from irritation of the lower and posterior portions of the nasal cavities. In two instances in which the sneeze-cough was very severe, the paroxysms were preceded by burning and tickling sensations, which the patients referred to the region above and behind the palate, where, upon examination, the posterior nares were very much congested and swollen, and exquisitely sensitive to the touch of the probe.

II. The Neuroses Proper of the nasal cavities may be divided into *Sensory*, *Motor*, and *Vaso-motor* (*neuro-vascular*, *sympathetic*). All these varieties may exhibit themselves simultaneously, or at different times, in the same individual, or each may appear as an isolated phenomenon. Care should be taken to separate (1) those which are of purely nasal origin, (2) those which depend upon central disturbance, and (3) those which result from irritation reflected from more or less remote regions of the body. Or, in other words, it should be clearly determined whether the neurotic symptoms referable to the nasal apparatus and its appendages be due to a purely local intra-nasal affection, or whether they be the symptomatic expression of a more central or general neurosis, and the proper relation as to cause and effect between the nasal symptoms and those referable to other parts of the system should be accurately and intelligently made out.

As the neuroses of the nasal passages may be peripheral, central, or essentially reflex in origin, their classification upon a strictly logical and scientific basis is a somewhat difficult matter. For purposes of convenience, however, and bearing in mind the fact that the three varieties are often combined in individual cases, they will be described in this article as above—sensory, motor, and vaso-motor.

A. Sensory Neuroses.—The sensory neuroses of the nasal chambers may be divided into those which spring from interference with the functions of the fifth nerve and those which depend upon some lesion or abnormal condition in the domain of the olfactory.

1. Neuroses of the Fifth Nerve.—1. *Anæsthesia.* Complete anæsthesia of the nasal mucous membrane is very rarely met with, and, when present, is due to paralysis of the fifth nerve from central trouble, as syphilis, brain tumors, extravasations, etc. Less frequently the anæsthetic condition is the result of pressure on the nerve after its exit from the cranium. Occasionally a more or less anæsthetic state of the nasal passages is encountered in atrophic conditions of the mucous membrane. Anæsthesia of the nasal passages is commonly associated with a corresponding absence of the sense of taste.

2. *Hyperæsthesia* is, on the other hand, a very common affection, and may be physiological or pathological. It is occasionally observed during a physiological epoch, as, for example, menstruation. Abnormal sensibility of the nasal mucous membrane may owe its origin to central or peripheral causes, or may be the result of reflected irritation from remote regions of the body. Excessive irritability of the nasal passages may be produced by neuralgic affections of, or pressure upon, the fifth nerve; it is often present in extremely neurotic, hysterical, and hypochondriacal persons. Almost any local pathological process in the nasal chambers is accompanied with varying degrees of hyperæsthesia, and the hyperæsthesic condition is especially well marked in the vaso-motor affections of the mucous membrane. It may also occur as a reflex vaso-motor phenomenon from irritation or disease of the eye, aural apparatus, lower respiratory, gastro-intestinal, utero-ovarian, and genito-urinary tracts.

II. Neuroses of the Olfactory Nerve.—The chief and most common of the olfactory neuroses is anosmia, or the loss of smell.

1. *Anosmia* may be congenital or acquired. When congenital both nostrils are commonly affected, and the loss of smell is complete and permanent, while in anosmia due to other causes the two sides may be equally or unequally affected, or the interference with olfaction may be limited to one nostril; the anosmia, too, may be complete or incomplete.

Congenital anosmia is generally due to absence or imperfect development of the olfactory nerves and bulbs, and it is conceivable that imperfect structural development of the olfactory region of the nasal passages themselves may be responsible for the anomaly, although no cases of this condition are, to my knowledge, as yet recorded.

Acquired anosmia may be due to centric or eccentric (peripheral) causes. Among central causes may be mentioned disease or wounds of the olfactory tract or centre, fracture of the base of the skull, dislocation of the olfactory bulbs from falls, concussion, etc.; compression of the anterior portions of the brain from tumors, abscesses, or hæmorrhagic, serous, muco-purulent, or fibrinous exudations; and plugging of the anterior or middle cerebral arteries (Hughlings Jackson,[2] Fletcher[3]). Partial or complete loss of smell may also result from atrophy of the olfactory nerve, either from disease or the degenerative processes of old age. Of central origin, too, may be regarded the loss of smell in syncope, hysteria, epilepsy, acute alcoholism, and other nervous affections.

All those influences that interfere with the physiological integrity of the olfactory region, or eliminate one or all of the conditions essential to the sense of smell, may be regarded among the eccentric or peripheral causes of anosmia. Thus (1) complete or partial destruction of the terminal filaments of the olfactory nerve, either from accident or disease, disappearance of pigment from the organ of Schultze (Hutchison,[4] Ogle[5]); (2) all obstructive lesions of the nasal passages and pharynx which prevent the access of the inspired air and odorous particles to the olfactory region, and (3) unnatural dryness or loss of moisture in the latter diminish correspondingly the power of smell, or may cause its complete disappearance.

Under the first class of causes may be mentioned abrogation or destruction of the conductivity of the olfactory nerves from swelling or ulceration of the mucous membrane, the presence of inflammatory exudations, atrophy of the olfactory region, absence of pigment in the olfactory cells, blunting of the sense of smell from wounds, incautious surgical interference, the injudicious use of powders and liquids in the nasal cavities (as, for example, the constant saturation of the nasal mucous membrane which accompanies the prolonged use of the nasal douche, syringe, and similar contrivances); the application of strong solutions of such substances as zinc, carbolic acid, iodine, alum, etc.; the constant inhalation of noxious gases or irritating particles of solid matter, mechanical and chemical, such as sewer-gas, ammonia, or ether; the habit of snuff taking; the inspiration of the floating dust in chemical works, etc.

Anosmia may also accompany the atrophic changes in the mucous membrane which follow paralytic conditions of the fifth nerve.

Under the head of obstructive lesions may be placed partial or complete closure of the meatuses from swelling, acute and chronic, of the mucous membrane and cavernous bodies; congenital or acquired malformations or abnormal positions of the septum and other portions of the bony and cartilaginous framework of the nostril; nasal, post-nasal, and pharyngeal growths and adhesions; foreign bodies; dried and accumulated secretion, crusts; inactivity of the dilatores nasi and orbicularis palpebrarum from paralysis of the facial nerve, etc.

The third class, finally, includes all those influences which cause an arrest of the secretion of the normal nasal halitus, or interfere with its properties as a solvent of odorous particles. Thus, in acute and chronic catarrhal inflammation the viscid, ropy condition of the exudation alters the physical quality of the nasal secretion and militates against the proper preparation of the odoriferous particles for contact with the olfactory nerves. In atrophic rhinitis, on the other hand, partial or complete anosmia may result from the dryness of the membrane and the disappearance of its glands and follicles.

The nasal mucous membrane is, as is well known, to a certain extent, supplied with moisture from the lachrymal apparatus. Anything, therefore, which interferes with the passage of the tears through the lachrymal duct will tend to militate indirectly against the proper appreciation of odorous bodies.

When no apparent cause can be made out for the loss of function, it is customary to describe the condition as "essential anosmia."

Symptoms and Diagnosis.—Bearing in mind the fact that anosmia is very commonly unilateral, the olfactory power of the two nostrils should be determined by separate tests. Care should also be taken to use only odoriferous substances, and not those which act by purely mechanical or chemical irritation.

The *pathology* and *treatment* of anosmia will obviously depend upon the lesion or condition of which it is the accompaniment or sequel; and the same may be said of the *prognosis* of the affection.

Parosmia.—Perversion of the sense of smell may be due to central or peripheral causes. Among the first class may be mentioned tumors, inflammation and degenerative processes of the brain or olfactory lobes, and hæmorrhagic or serous exudation in the fore-part of the cerebrum, or in the region of the olfactory nucleus. Of central origin may be regarded, too, the olfactory hallucinations of the insane, and the curious disturbances of olfaction met with in the hypochondriacal and hysterical. Parosmia constitutes not infrequently the aura or premonitory symptom of an epileptic attack, or it may only make its appearance at the close of the paroxysm. The various idiosyncrasies in regard to olfaction may also be referable to central disturbance.

Of peripheral causes the most common are acute and chronic catarrhal rhinitis, or new-growths of the nasal fossæ. In all cases there is a neurotic element present which must be looked upon as an essential etiological factor.

The pathology of parosmia is obscure. Future research will doubtless discover in some cases an essential anatomical lesion; but in many others the explanation of the condition must be sought for in the domain of metaphysics.

The prognosis will depend upon the cause, and the rational treatment involves the elimination, if possible, of the same.

B. Motor and Vaso-motor Neuroses (Nasal Reflex Neuroses—Coryza vel Rhinitis Sympathetica *).—Within the past few years the attention of the medical world has been more prominently called to a series of morbid phenomena, some directly referable to the nasal apparatus, others to regions of the body more or less remote from the nose, which seem to depend upon irritation or well-marked structural changes in the intra-nasal tissues, and which not infrequently disappear after removal of the source of irritation within the nasal cavities. These seemingly purely neurotic conditions have received the name of the *nasal reflex neuroses*, and embrace a host of sensory, motor, and vaso-motor phenomena, varying greatly in nature and anatomical sphere of operation. Various neuralgic conditions of the branches of the fifth and other nerves, cough, asthma, vertigo, nightmare, "hay fever," various spasmodic affections, general convulsions, diseased states of the nose, eye, ear, larynx, and bronchial tubes, symptoms referable to irritation of the gastro-intestinal, utero-ovarian, and genito-urinary tracts, even chorea, epilepsy, melancholia, retarded sexual development, and exophthalmic goitre have been mitigated or known to disappear with the cure of the nasal affection.

While in some of the recorded instances of these "reflex nasal neuroses," the enthusiasm and hasty judgment of the reporters have carried them too far, and while in many cases the direct connection between the nasal disease and the reflected phenomena is not sufficiently evident, still the fact is established beyond the possibility of doubt that a causal relationship often does exist between certain conditions of the nasal passages and other portions of the respiratory tract, and a host of phenomena referable to other and remote organs of the body—a direct dependence or connection which justifies us in the belief of their reflex reciprocal relationship.

These affections are sensory, motor, or vaso-motor in nature. As all these varieties are intimately associated, and as their separate discussion would involve ceaseless repetition, they will be considered in this article under the common head of the reflex nasal neuroses.

At the present day, when, by common consent, our knowledge of this class of affections is confined within the narrow limits of scarcely two decades, it may be interesting to glance for a moment, away from the writers of the present epoch, to the literature of more remote times.

Historical Sketch.*—"Nullum est jam dictum, quod non dictum sit prius" (Terence). "Multa renascentur, quæ jam cecidere" (Horace). In the "Symposium" [6] of Plato, when the time came for Aristophanes to speak, he was seized with the hiccups, and upon requesting Eryximachus to stop them and speak in his stead, was told that, be the hiccups ever so violent, if the nose were tickled they would cease at once. This popular recognition of the sympathy between the nose and diaphragm is also distinctly affirmed in the sixth book of the "Aphorisms" of Hippocrates: "If sneezing comes upon a man in a fit of the hiccups, it puts an end to the disorder." [7]

The consensus or sympathy between the nose and eye seems also to have attracted popular attention. Thus Aristotle [8] devotes two paragraphs of the thirty-third section of his "Problems" to the consideration of the question why rubbing the canthi of the eyes puts an end to sneezing. Avicenna,[9] to prevent sternutation, recommends rubbing the eyes, ears, extremities, and palate; while Rhazes,[10] in his chapter on acute and chronic obstruction of the nose (*De Alcasem*), mentions, among the symptoms of the latter, abrogation of the sense of smell, with a coexisting diseased condition of the eyes. Rhazes also recommends the induction of sneezing, "when the mouth is convulsed and drawn to one side," [11] and mentions the fact that running at the nose, a cold in the head, and hoarseness may occur from the odor of violets, etc.[12]

The relation of certain affections of the head, and notably hemicrania to congestion, and even inflammatory disorders of the nasal apparatus, seems also to have been foreshadowed in the writings of the earlier physicians. Thus, in the "Medical Compositions" of Scribonius Largus † is found the following direction for the cure of

* The substance of this section was communicated to the Clinical Society of Maryland in April, 1885, and an abstract of the paper was printed in the Maryland Medical Journal of April 11th of the same year.

* In the American Journal of the Medical Sciences for January, 1886, I have given an account of the earlier literature of so-called "hay asthma" and "rose cold."

† Scribonius Largus: De compositionibus medicamentorum, liber unus. Parisiis, 1529. Ed. Vuechel, comp. vi. The ancients included under the generic term headache the affections known as cephalalgia, cephalea, and hemicrania or heterocrania, the latter term being employed by Aretæus (De caus. et sig. morb. chron., liber i., cap. ii.). Aretæus says the sense of smell is vitiated in heterocrania.

certain forms of headache: "Oportet vero permanente capitis dolore, materiam quoque detrahere ex eo nares, vel os."

The dependence of catarrh, coryza, asthma, syncope, convulsions, and a host of other phenomena upon the presence or odor of roses, lilies, peonies, and other flowers, has been recognized for centuries. For, although Pliny * informs us that the seed of the rose inhaled into the nostril has the effect of clearing the brain, there are many cases to be found among the older writers in which the odor of various substances, such as the rose, has been known to result in epilepsy, syncope, and even death,† and there is a tradition that the Roman ladies conceived an especial aversion to the odor of the queen of flowers.

The diagnostic acumen of Galen[13] led him to the observation that in certain persons the presence of various foods is sufficient to excite a coryza, and, scattered here and there through the literature of succeeding centuries, isolated cases are found in which similar peculiarities in regard to flowers and other objects are recorded.‡

In the light of our present knowledge of the affection known as "hay fever," it is scarcely conceivable that it made its first appearance at the beginning of the present century. As Dick, and afterward Matthew Baillie, thought that in describing their first cases of laryngitis they had discovered a new disease, so Bostock, in portraying the symptoms of "*Catarrhus æstivus*," was led into a similar error. For no one can arise from the perusal of the older writers on asthma without the conviction, or, at least, the suspicion, that this disease has descended to us through the centuries as a species of the "convulsive asthma" and "periodic coryza" of the more ancient nosologists, who, in their state of medical science did not resort to the nosological refinements which proceed from the more advanced pathological research of the present day and century.

I have shown elsewhere[14] that the so-called "idiosyncrasy," by virtue of which the presence or odor of certain flowering plants is sufficient to create disturbances referable to the nasal chambers and other portions of the respiratory apparatus, was familiar at a remote period of medical history. In the days when medical writings were published in Latin, the necessity of recording one's observations in a foreign tongue led to a terseness of style and incompleteness of description which often surrounds with uncertainty the exact nature of the cases reported; but whether the records referred to were examples of true vaso-motor coryza or not, they may be placed in the same category of affections, and the predisposing influences may be considered identical with those provocative of the disease called in the present century "rose cold."

To Voltolini (1871) is universally and erroneously attributed the credit of pointing out the interesting relationship between asthma and nasal disease. I have shown elsewhere,[15] however, from the writings of Aurelian, Zecchius (1650), Schneider, Floyer (1726), Bree (1811), Trousseau, Follin and Duplay, and Ferber (1869), that the association of these two conditions was known long before the time of Voltolini. Among these writers Ferber, referring to the frequent association of sneezing, migraine, hay fever, and bronchial asthma, advanced the theory that these phenomena were the expression of a neurosis of the trigeminus nerve—a view which has recently been resurrected in a modified form by Schadewaldt (*vide infra*).*

In 1682 Wedel[16] treated of the association of vertigo and sneezing, and in the same year Van Helmont,† in several chapters of his work, discussed the effects of sweet odors in the production not only of epilepsy, but headache, nausea, vomiting, cough, hiccup, vertigo, apoplexy, dysentery, and other affections. He also alludes to the fact that, while sweet odors give rise to asthma in some, in others they produce, instead of asthma, hemicrania, palpitation, and syncope. This writer regards such disturbances as of frequent occurrence, and is looked upon by some as the first to recognize the affection known as "hay asthma."[17]

In the early part of the last century Baglivi[18] called attention to the fact that irritation of the nostrils by snuff (or tobacco) may provoke a desire to go to stool. This same observer also called attention to the association of asthma and urticaria (see below, under Pathology).

A few years after the publication of Baglivi's work Gumprecht[19] discussed the sympathetic troubles connected with the inhalation of vapors into the nostrils, and explained them on the theory that the vapor taken into the nose affects preternaturally the branches of the fifth pair of nerves, and is reflected to the fauces, stomach, heart, and lungs through the medium of the intercostal and eighth pair (Willis).

This nerve theory, which was the outcome of the neuro-pathology of Willis[20] and Vieussens,[21] was subsequently insisted upon by Henricus Josephus Rega, in an elaborate general discussion of the sympathies between the different organs of the body.[22]

During the first part of the last century there appeared a ponderous work by Johan Jacob Wepfer,[23] consisting of a collection of cases illustrative of the external and internal diseases of the head, in which the relationship of hemicrania and other pathological phenomena to nasal inflammation and obstruction was distinctly and emphatically announced. Nothing seems to have escaped the far-reaching experience and accurate observation of this writer, to whose powers of description and diagnostic acumen it would be difficult to do justice within the limits of this review. So instructive is every case and page that it is hard to make a selection, and I shall, therefore, only refer briefly to the following:

Obs. 34, pp. 75, 76. Association of cephalalgia with sternutation, screatus, cough, and coryza, supposed to be due to irritation of the dura mater.

Obs. 36, pp. 80–82. Paroxysms of violent headache, vertigo, pain from the nucha to the head, debility of memory and vision, tremor, cough, pain in the eye and about the nose, due to obstruction of the nostril from abuse of tobacco, which caused retention of mucus within the nostril, and awakened the above symptoms from the sympathy of the latter with the meninges about the torcular herophili.

In this case the mucus retained in *the deeper portions*

* Nat. Hist., lib. xxi., cap. 73. The same writer (lib. vii., cap. 7) also observes that the smell of a lamp which has been extinguished will often cause abortion, and that the latter ensues should the female happen to sneeze just after the sexual congress.

† While there is a remote possibility that this observation of the ancients, which finds its reflection in the poetic imagery of Pope, may have some slight foundation in fact, it is extremely doubtful whether, in the cases referred to, death was due to the simple inhalation of the odorous particles of the flower, for in some of the recorded instances the victims were confined to closed chambers, and were possibly poisoned by the displacement of the oxygen of their bedrooms by the noxious exhalations from the plants. It should also be remembered that our less civilized and punctilious brother-man of a few centuries back did not hesitate to dispose of an enemy through the covert instrumentality of poisoned flowers and other equally insidious devices, by means of which the deadly agent was introduced into the system through the respiratory mucous membrane.

‡ In certain individuals, or even families, this peculiar antipathy or susceptibility to particular flowers or foods takes the form of nose-bleed; in others violent purging occurs, or even epileptiform convulsions.

* The association of epileptiform seizures, or even true epilepsy, with some irritation in or about the nasal passages, or peculiar susceptibility on the part of certain individuals to be thrown into epileptic convulsions through the application of some forms of matter to the nasal mucous membrane, seems to have been familiar from the earliest times. We learn, for example, from Aretæus (De causis acut. morborum, lib. i., cap. 1, Ed. Boerhaave, Lugd. Bat., 1735) that the gagate stone (a species of hard coal or jet) was utilized by the ancients as a test for epilepsy, for when applied to the nostrils the sufferer was thrown into epileptiform convulsions. Pliny (l. b. xxxvi., c. 34) also alludes to this test, and to the power of the smell arising from burning goat's horns or deer's antlers in accomplishing the same result (lib. xxviii., cap. 63). According to this historian the secundines of a she-ass, placed under the nostrils of the patient when the fit is approaching, will effectually dispel it. It is also a curious historical fact that Avicenna (Op. omn., Venet., 1608, l.b. iii., Fen. i., tract. v., cap. 8, p. 109) mentions (l. c., Fen. v., tract. ii., cap. 15, p. 585) "rosa cum suis pelis" among the milder measures resorted to to provoke sternutation, and regarded sneezing itself as a mild form of epilepsy (*epilepsia levis*), and that a similar opinion was entertained long afterward by the learned Fernelius (Medicina, Lutetiæ Parisiorum, 1554, de epilepsia).

† Johan Baptist van Helmont: Op. omnia, Francofurti, 1682. Imago fermenti impregnat massam seminæ, p. 110, § 10, p. 344, § 10, and p. 348, § 41. This author also refers to the case of a monk, employed in pulling down buildings, who grew asthmatic from the constant inhalation of dust.

of the nostrils (profundè intra cavernas narium retentus et inspissatus ab aëre ex pulmonis expirato præservido) was supposed to draw the meninges into consent.

Obs. 38, pp. 84, 85. Association of pains in the head, tinnitus, pains in the humerus, various nervous symptoms, and vomiting, with inflammation of the fauces. A very interesting case.

Obs. 40, pp. 94. Says he has frequently observed hemicrania due to obstruction of the nares.

Obs. 42, pp. 100–102. Case in which intense paroxysms of periodic cephalalgia and hemicrania were preceded by stupor of the head with gravedo. The patient suffered from obstructed nostrils, with tendency to somnolence and delirium. When the acme of the paroxysm was reached, vomiting of a tenacious mucus with bile occurred, with relief to the symptoms.

Obs. 43. Case of a man suffering from obstructed nares, who was troubled for seven years with daily pain in the head in the morning, when he arose from his couch, to which were soon added heaviness of vision, vertigo, tinnitus aurium, debility of the joints, with tremulous movements of the same. These symptoms were relieved by drawing the mucus from the head and nose into the fauces. The mucus was removed with difficulty, owing to the narrowness of the nostrils from obstruction. He explains the case on the theory of sympathy, and laxity of *the pores in the spongy bones.* Wepfer believes the trouble to have been an invasion of the spongy (turbinated) bones, and observes that in such cases the indication is to remove the inspissated mucus from the nares. A most interesting case.

Obs. 44. Hemicrania from an acrid serous discharge.

About the middle of the last century Daniel Langhans[24] published an elaborate dissertation, which deserves special mention, in which he adverts to the rôle of the superior cervical ganglion in the evolution of sympathetic (reflex) acts, such as asthma, cough, etc., from irritation of the stomach, uterus, and other organs of the body.

In 1760 Morgagni[25] explained more fully the sympathy between the nostrils and the diaphragm and abdominal viscera, calling attention at the same time to the communication between the fifth pair of nerves and the intercostals (Willis). In illustrating his theory, he called attention to the case of a nobleman in whom epileptiform convulsions were preceded by a fetid smell only perceptible to himself; also to that of an old drunkard who sneezed for two or three years, for a quarter of an hour each day, and finally died suddenly. On post-mortem there was discovered hypertrophy of the heart.[26] In another place he tells of a man of forty, an habitual drinker, who suffered for some time from dyspnœa (asthma), with frequent and severe fits of sneezing. One day, in a paroxysm of sneezing, he felt a sudden contraction of the heart, sneezed once more, and died.

In 1761 H. Boerhaave,[27] speaking of sneezing in connection with intestinal parasites, makes the assertion that if a healthy man fasts longer than is his wont, he feels a disagreeable sensation about the præcordia, *sneezes*, and then vomits. Following Avicenna, he compares the sneezer to the epileptic. In the same year Thomas Bartholini[28] tells us that, after phlebotomy, when the wound is closed and the cicatrix is yet tender, some are taken with sneezing. In commenting on this remarkable association he states that he has observed sneezing during coitus.

In 1765 appeared a thoughtful treatise on nervous diseases by Robert Whyte,[29] of Edinburgh, in which he calls attention to the fact that "several delicate women, who could easily bear the smell of tobacco, have been thrown into fits by musk, ambergris, or a pale rose, which, to most people, are either grateful, or at least not disagreeable" (p. 125). He also mentions similar antipathies in regard to cinnamon and other substances. Whyte alluded to the sympathies between the larynx, pharynx, and ear, and advanced the doctrine that the impressions made upon the terminal filaments of the nerve (as, for example, in ear cough) must be first referred as a particular feeling to the sensorium commune, before being reflected to other parts of the body.

In 1785 Tissot[30] called attention to the fact that very violent paroxysms of migraine are sometimes terminated by slight hæmorrhage from the nose, and relates the case of a man of his acquaintance, an habitual sufferer from migraine on the same side in which he had a polypus in the nose, and to which it owed its origin.[31]

In 1797 we find Darwin[32] reporting a case of nasal polypi, due to the irritation of worms in the intestines; and, in 1801, Gruner[33] alludes to sneezing in hysterical women as a prodrome of the attack, and in retention of the after-birth; to the same reflex in the dissipation of cough, hiccup, and allied evils; to its occurrence in those suffering from hernia, in pregnancy, and skin eruptions. This writer says[34] the nose becomes warm and red in the hysterical, in women at the menstrual period, and in the victims of onanism.

In 1802 Heberden[35] observes that "a large suppuration of an inflamed sore throat has been attended with a considerable quantity of pus at the bottom of the vessel which held the urine, for three or four days. As soon as the abscess broke and discharged itself, this purulent appearance in the urine ceased." Heberden, as is well known, was supposed to have approached very nearly the discovery of the disease known as "hay fever."[36]

In 1804 Deschamps[37] maintained the view that hemicrania is a disease of the frontal sinus, and related some experimental observations illustrative of the great sensibility of this cavity; and in the same year Portal observes that he has seen pains, vertigo, and even epileptic affections in connection with disease of the nasal membrane, and refers to a case accidentally cured by the fumes of cinnabar, given with other intention.

The limited space allotted to the present article precludes a critical review of the diversity of opinion with which the different theories concerning these neuroses have been received. Those who wish to familiarize themselves with the recent literature of the nasal reflex neuroses should consult, in addition to the writings already referred to, the subjoined list of articles which represent the principal contributions to the discussion of the subject.

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In 1871 Voltolini,* of Breslau, reported a case of asthma cured by removal of nasal polypi—an observation which attracted considerable attention, and which was followed, shortly, by communications on the relation of asthma to nasal disease, by Hänisch,[39] Porter,[40] H. Hartmann,[41] Schäffer,[42] Daly,[43] Spencer,[44] Todd,[45] B. Fraenkel,[46] Mulhall,[47] Porter,[48] Rumbold,[49] Joal,[50] Jacquin,[51] Bresgen,[52] and others.

Among these writers Porter called attention to the rôle of hypertrophic nasal catarrh in the production of asthma, and pointed out the fact that obstruction of, or irritation in, the nares may cause the reflex affection, apart from the presence of a polypus. Among Rumbold's cases was one in which attacks of so-called "hay fever" were dissipated with the cure of the nasal disease. The mechanism of the asthmatic attack was variously interpreted. According to some, the irritation of the sensitive nerves in the pharynx and larynx by mouth-breathing, and the creation of a vacuum behind the seat of nasal obstruction, originated the impression, which was conveyed to the pulmonary branches of the pneumogastric; while others adopted the more natural explanation of irritation directly reflected through the sensitive branches of the fifth nerve.

In May, 1881, at the meeting of the American Laryngological Association, Dr. William H. Daly,[53] of Pittsburg, called attention to the fact that in a fair proportion of cases of "hay-asthma" there is local disease of the nose and nasal pharynx (from simple hyperæsthesia to pronounced structural changes, such as hypertrophic catarrh, polypi, etc.), without which the exciting cause (pollen, bacteria) is innocuous, and that the cure of the affection may be accomplished through removal of the local intrinsic condition (by cauterization with acid, electric cautery, etc.)—a position which he established by most convincing practical proof. To this observer belongs the credit of formulating the treatment of the disease by measures addressed to the nasal and naso-pharyngeal chambers. According to Daly, we are only justified in looking upon "hay fever" as a neurosis when the affection persists after removal of the local nasal disease. Daly attempted no explanation of the mechanism of the disease, but simply announced a clinical fact and the treatment based upon it.*

The following year, Dr. Roe,[54] of Rochester, published the successful results of his treatment of the disease by the operative method, and related a number of cases in which a cure had been effected. According to him, the affection is due to the action of pollen upon the nasal mucous membrane, which in some persons is rendered peculiarly susceptible by active or latent disease of the naso-pharynx associated with hypertrophic catarrh of the nasal passages. The asthma and other manifestations of the paroxysm are due, he believes, to reflex congestion of the mucous membranes of the several organs in which their effects are manifested. While Dr. Roe believes the exciting cause to be pollen, he at the same time contends that, in order to the production of a paroxysm, "latent or active" nasal disease must be present, that

* Dr. Edson (letter to N. Y. Medical Record, 1878, vol. ii., p. 317) had previously called attention to the fact that all cases of the disease presented one or more of certain symptoms referable to the nose, such as great sensitiveness of the nasal membrane, coryza, persistent sternutation, naso-pharyngeal catarrh, etc.

the nervous symptoms are secondary to the hyperæsthetic condition of the nostrils, and that the latter is not the effect but the cause of the neurotic feature of the disease.

At the meeting of the Verein der Aerzte Steiermarks, 1881, Dr. Josef Herzog [65] advanced the view that "hay-asthma" is simply a form of the neurasthenic condition described by Beard, and held that local treatment is of secondary importance.

In the same year in which Roe's papers appeared I published the results of some experiments made by me with reference to the production of nasal cough and the localization of reflex sensitive areas in the nasal passages, which, I ventured to think, threw some further light upon the subject of reflex nasal neuroses. These observations, and the views of Professor Hack upon the subject, have already been considered at the commencement of this article. Hack's able monograph, which was published in Wiesbaden in 1884, was based upon a series of instructive cases, including nightmare, asthma, migraine, cough, muscæ volitantes, supra-orbital neuralgia, vertigo, epilepsy, swelling and redness of the external nose, "hay-fever," etc., reported in the *Wiener Medizinische Wochenschrift*, in the latter part of 1882 and in 1883, and is a most valuable contribution to the literature of the nasal reflex. It excited a great deal of comment, and was followed rapidly by a number of communications on the subject.

Hack holds that the reflex excitability of the mucous membrane in this class of neuroses is dependent solely upon the tendency to sudden swelling of the cavernous bodies, and he explains the mechanism of the reflex as follows: When an irritant is applied to the nasal mucous membrane, the first thing that happens is swelling of the erectile bodies from a determination of blood to their cellular spaces. The extreme tension of the mucous membrane, thus brought about by the engorgement of the cavernous bodies beneath it, acts as the exciting stimulus to the terminal filaments of the sensitive nerves, with the subsequent production of the reflex. The chain of events is then (1) swelling of the cavernous bodies; (2) tension of the mucous membrane; (3) irritation of the terminal nerve-filaments; (4) the reflex phenomena. Hack maintains, furthermore, that should the irritation start from portions of the mucous membrane other than that covering the anterior end of the turbinated bone, the swelling in the latter circumscribed situation occurs only indirectly or secondarily through the influence of "nervi erigentes." This turbinated engorgement then forms the connecting link between the nasal symptoms and those referable to other parts of the body, and *must* be present in order to the production of the reflex. As the presence of an inflammatory condition prevents or interferes with the cavernous swelling, he maintains that the frequency of nasal reflexes is in inverse ratio to inflammatory conditions of the mucous membrane.

Like Daly and Roe, Hack holds that morbid conditions of the nose itself play the essential part in the etiology of the disease, and believes that the neurasthenic symptoms are secondary to the nasal affection, calling attention at the same time to the fact that the latter may coexist with a general neurosis without having any connection with it.

In 1884 a still more exclusive view was put forth by Dr. Harrison Allen, of Philadelphia.

According to Allen, "hay-fever" and allied neuroses depend solely upon obstruction of the nostrils (from deflection of the septum, hypertrophy of soft parts and bone, turgescence of the nasal mucous membrane), and that the cure consists simply in removing the obstruction (or tendency thereto) in the nasal chambers. According to his experience, sufferers from these affections have one feature in common—the inferior turbinated bones lie well above the floor of the nostril, an anatomical peculiarity which subjects their overlying mucous membrane to additional irritation from extraneous substances.

It would appear, then, that the truth is irresistibly emerging into recognition that certain abnormal conditions of the nasal passages are necessary to the production of the *ensemble* of phenomena which form the clinical picture of so-called hay-asthma and allied nasal neuroses. Although the results arrived at by different observers, working independently of each other, and starting out in some instances from different stand-points, are not altogether harmonious, they present, nevertheless, a singular unanimity in their convergence to a common point—in their recognition of the importance of remedial measures addressed to the nasal chambers as a prime factor in the therapeutic management of the disease.

Several months after the publication of Dr. Allen's view I endeavored to reconcile the discrepancies met with in the results of different observers,[66] and in several subsequent publications advanced the doctrine which is advocated in the present article (see Pathology and Treatment).

NOTE.—Since the completion of the above historical sketch, Dr. Schadewaldt, of Berlin (Die Trigeminus-neurosen, Deutsche med. Wochenschrift, Nos. 37 and 38, 1885), has advanced a theory very closely resembling the one insisted upon by Ferber, of Hamburg, in 1869 (see Historical Sketch). According to Schadewaldt, "nasal asthma," cough, and various other well-known nervous phenomena referable to the respiratory tract are to be regarded as the symptoms of a neurosis of the trigeminus nerve, as functional disturbances of the normal reflex function of sneezing—"qualitative changes with quantitative exalted reflex excitability." To illustrate—the physiological results of irritation of the nasal fossæ are, in the order in which they occur, swelling, secretion, sneezing. It often happens, however, as in chronic inflammation, that only one of these elements (swelling) is present, sneezing and secretion being replaced by cough, which latter may be regarded as their pathological vicarious representative. This cough, then, may be looked upon as the pathological inversion of the act of sneezing, and the rational method of therapeutic procedure would therefore involve, for the dissipation of the cough, the production of both secretion and sneezing. Asthma likewise represents a pathological disturbance of the normal nasal reflex. Schadewaldt's observations on the subject of cough tend to substantiate, essentially, the results arrived at by me, viz.: that the lower and posterior parts of the nasal fossæ are the spots generally most sensitive to the reflex-producing impression.

Since the appearance of Schadewaldt's article, Dr. Bosworth (N. Y. Med. Journal, April 24 and May 1, 1886), of New York, has modified the obstruction-theory as follows: Bosworth argues that, as the mucous membrane of the air-passages is endowed with no special secretory apparatus, and as its glands secrete mucus alone, the surplus moisture taken up by the inspiratory current during the day cannot possibly come from that structure. As, furthermore, the delivery of such a large amount of moisture to the inspiratory current by the respiratory membrane would involve the destruction of the latter by producing excessive dryness, he assumes that the erectile tissue of the turbinated bodies is endowed with that peculiar privilege, and that "the respiratory function of the nose is simply an exosmosis of serum." Starting out with this physiological postulate, he theorizes as follows: The essential anatomical feature in this class of cases is stenosis of the anterior portions of the nasal fossæ. In such an event every act of inspiration causes rarefaction of air behind the point of obstruction, from diminution of atmospheric pressure and the production of a vacuum (as pointed out by Andrew H. Smith), and that not only in the nasal cavities, but along the whole naso-bronchial tract. This finally begets a tendency on the part of the mucous membrane "to sag down or pouch into the cavity," a condition attended with dilatation of the blood-vessels, especially those of the turbinated tissues, and tending to local inflammation—a sort of dry-cupping process, as it were. This results finally in a weakening of the muscular fibres which regulate the calibre of the vessels, and "their escape, to a certain extent, from the control of the vaso-motor nerve"—a vaso-motor paralysis which leads to an enormous transudation of serum, with a sodden condition of the membrane, and "an unlocking of the whole activity of the respiratory function," which causes a "flooding of the membrane rather than a flooding of the cavity, and therefore causes extreme turgescence of the blood-vessels, with complete stenosis of the passage." The sodden, prolapsed membrane pressing on the terminal nerve-filaments gives rise to the nervous phenomena. Although the latter are the result, therefore, of nerve-pressure, Dr. Bosworth, singularly enough, denies that a reflex agency is necessary to their production (see N. Y. Med. Journal, February 26, 1887, p. 246); indeed, he is disposed to think there is no such thing as a reflex disorder, and considers that "direct continuity of surface from the nasal chambers to the bronchial tubes," and a relation between the blood-vessels of the larynx and those of the nose, so that a close sympathy exists between them, are sufficiently explanatory of the fact that congestion in one place may produce congestion in another.

The fallacies involved in the obstruction-theory will be sufficiently indicated below. Unfortunately for its advocates, in a large proportion of cases there is no nasal obstructive lesion whatever. The view violates the two most essential criteria of a logical hypothesis—the facts do not exist, and the assumption is inadequate to even partially explain the phenomena. To take one of a multitude of illustrations, how could rarefaction of air in the bronchial tubes, the result of nasal obstruction (even admitting the existence of such a fact) or of direct continuity of the nasal and bronchial tissues, account for the sudden and immediate production of a paroxysm of asthma, cough, or other reflex disorder from the simple contact of a probe or other indifferent substance with the nasal mucous membrane—a result which I have often observed?

ETIOLOGY.—*Age; Sex; Condition of Life.*—No age or condition is exempt. I meet with these reflex phenomena at all ages and in every condition of life, in private and in hospital practice. While the majority of cases

that apply for treatment come from the educated classes, it must not be forgotten that it is precisely persons of this class that seek intelligent medical advice or are likely to come across circulars distributed by those investigating the complaint. Several of my patients dated their trouble from infancy, and two of the most distressing and typical instances of asthma and vaso-motor coryza first appeared at the ages of two and three months respectively. I find these neuroses more common among women than is generally supposed, and am inclined to regard the question of sex as one of unimportant etiological significance.

Inheritance; Family Peculiarities.—I think there can be no doubt that a peculiar excitability or deranged condition of the nerve-centres may descend from father to son, and determine the appearance of the affection in the latter. The question of inheritance in regard to periodic vaso-motor coryza has been established beyond all question by the able researches of Wyman[57] and Beard,* and my own observations not only support their conclusions in this direction, but also demonstrate the certainty of transmission of other members of the group of "reflex neuroses" from generation to generation. It is not uncommon to find several members of the same family similarly affected, and it not infrequently happens that one or both of the parents of children suffering from this class of sympathetic rhinal disease either bear the exact reproduction of the affection in their own persons or labor under some allied respiratory neurosis. In a fair proportion of cases it will also be found that more remote relatives of the individual suffer from asthma and various other nervous conditions. In other instances the general family temperament is essentially neurotic, with a tendency to epilepsy, chorea, or some other pronounced nervous affection.

Temperament.—The predominant temperament among individuals affected with these reflex neuroses is unquestionably the neurotic. While they may, in many instances, not necessarily belong to the so-called "nervous" or "hysterical" variety of individual, while they may give no outward and visible sign of a deranged nervous system, there will generally be found, on careful examination, a delicacy or sensitiveness of the nervous apparatus, either in whole or in part.

Race Peculiarities; Origin.—Taking the view which I do of these affections, it does not seem to me justifiable to confine the operation of their causes within the limits of a particular century, or to explain their phenomena on the hypothesis of national or race peculiarities.

More accurate observations are necessary to the formulation of definite conclusions concerning the occurrence of these neuroses in the inferior races. While it is doubtless true that the physical and moral forces of civilization encourage their development in the higher walks of life, they probably do so only in so far as they predispose to abnormal excitability of the nervous system in general, or to catarrhal and asthmatic affections.

The absence of so-called "hay-fever" in the negro has been brought into prominence by recent writers on the subject, and notably by Beard, as an argument in favor of the important rôle which race is supposed to play in the etiology of that disease. I have recently,[59] however, pointed out the fact that this race is by no means exempt from this curious disease, and I now and then meet with reflex phenomena in the negro, referable to disease of the nose and belonging to the same category of affections; and it is possible that a fair proportion of cases of the convulsive asthma which occur in that race may have a similar origin. One of the most pronounced cases of "reflex asthma" which I have ever seen, and in which the asthmatic paroxysm could be produced at will by irritation of the nasal sensitive area with the probe, occurred in the person of one of the blackest representatives of the Ethiopian race. In this people the exquisite delicacy of the sense of smell, the prominent development of the turbinated bodies, and the consequent increased amount of surface exposed, would seem to invite the paroxysm in those surrounded by the conditions that provoke it.*

Structural Peculiarities.—In persons affected with the sympathetic forms of coryza or rhinitis, the mucous membrane of the nasal passages, and, in some instances, of the whole respiratory tract, is the seat of a peculiar hyperæsthesia, whose origin and characteristics will be more fully discussed, later on, under Pathology.

During the paroxysm this hyperæsthesia is altogether out of proportion to that which is ordinarily met with in simple inflammation of the nasal passages, and is often increased by remedies which ordinarily control effectually the deranged sensibility of simple coryza or chronic rhinitis. Indeed, in a large number of the class of cases commonly known as "reflex nasal neuroses" this irritability is so exquisite as to render the contact of the blandest applications unbearable to the patient, and this apart from the presence of any of the exciting causes of the paroxysm. This often renders the topical treatment of existing nasal disease a matter of considerable difficulty, not only at the time of the paroxysm, but also in the interregnum of so-called immunity. It also often predisposes to coryza from apparently trivial causes.

The hyperæsthesia is commonly associated with a marked tendency to erection of the corpora cavernosa; and both hyperæsthesia and cavernous engorgement I believe, in opposition to Daly, Roe, and Hack, to be purely secondary phenomena, dependent, in all probability, upon some central irritation or paresis (see, also, section on Pathology).

The swelling of the corpora cavernosa is not, therefore, absolutely necessary to the production of the nasal reflex, and must be considered, in many instances at least, not the originator, but the vaso-motor accompaniment of the reflex act. Repeated or permanent engorgement of these bodies undoubtedly predisposes to and increases the reflex irritability of the nasal fossæ, and their erection may precede, in point of time, the evolution of the reflex act; but it is at the same time equally true that the latter may occur without any change in the cavernous bodies appreciable to the eye.

I have not been able to discover any structural peculiarities in the skeleton of the head which might serve to differentiate this class of cases from other intra-nasal processes. While in some the inferior turbinated bones, as pointed out by Harrison Allen, lie well above the floor of the nostril, I am inclined to regard this elevated condition as an inconstant anatomical feature.

Glasgow[60] has observed in cases of sympathetic rhinitis an abnormal pallor of the mucous membrane, which he explains on the theory of spasm of the arterioles—due to an increased vascular tone caused by an augmented action of the vaso-constrictors. With this arterial spasm occurs general arterial tension, the onward flow of the more solid portions of the blood is prevented, and the cavernous bodies of the mucous membrane become infiltrated with escaping white corpuscles and the liquor sanguinis. This view, he thinks, is supported by the favorable action of remedies which cause arterial dilatation, such as atropin and amyl nitrite. This prominent feature—*i.e.*, pronounced paleness—disproves, he believes, the possibility of congestion of the cavernous bodies.

In the class of cases we are discussing, the nasal passages may be entirely free of any well-defined structural lesion; or, on the other hand, may be the seat of almost any pathological process met with in these cavities. A common condition is the hypertrophic stage of ordinary inflammation, or pronounced congestion of the mucous membrane, more marked over the area of the cavernous tissue. In another case we find a deflected septum, an unusually prominent turbinated bone, or other deformity of the intra-nasal framework; in still another, one or more nasal polypi, and so on. Sometimes the nasal fossæ are more or less completely obstructed, while in others the lumen of the nostrils is normal or even very

* Since reporting my first case of "hay-asthma" in the negro, two similar cases have come under my observation.

capacious. Atrophic conditions are very seldom met with;[61] very extensive atrophy I have never seen.

The rôle of intra-nasal disease in the production of reflex phenomena will be considered under the head of Pathology.

The appearances of the pharynx and lower air-passages will depend usually upon the diseased condition of the nasal fossæ, and may accordingly be of the most manifold nature.

Symptoms. — *General Characteristics.* — The attacks which characterize the affection are paroxysmal, occasionally showing a decided tendency to periodicity, and may occur at any time, but more commonly at night, when the recumbent posture is assumed, or when the patient lies on the more affected side. Varying greatly in duration from a few moments to several hours, the paroxysm either passes off spontaneously or is terminated by sneezing, with or without a copious discharge of mucus or serum from the nostrils. Several attacks may occur during the day or night, except when the paroxysm is prolonged, in which event only one seizure takes place during the twenty-four hours. The onset may be sudden and without warning, or it may be preceded by a variety of sensations either referable to the nasal apparatus itself or to a distant organ. Under the former head may be mentioned sneezing, itching, tickling, sense of a foreign body present, dryness or fulness of the nasal passage or throat, or sudden and complete stoppage of one or both nasal passages. Under the latter are itching and other sensations in the eyes or ears, or a sense of formication in various parts of the body, and a sense of fulness, dulness, or even pain in some organ remote from the nasal fossæ.

There are generally one or more symptoms which possess more prominence than the others; or a number may be prominently associated in the same individual, notably in the case of coryza vasomotoria periodica. The grouping together of several of the more common symptoms of this disease was formerly, and is now generally, known as hay-asthma. In some persons they only appear in connection with some physiological process, as menstruation, coitus, etc.; in others, only during certain months of the year or in the presence of brusque temperature-changes. When the paroxysms show a decided tendency to periodicity, coming on at or about the same hour every day, it will be observed that in this case a more or less pronounced neurotic temperament is present, and that apart from any so-called hysterical manifestations.

Analysis of Individual Symptoms.—Symptoms Referable to the Organs of Special Sense. Nasal Apparatus. The most prominent symptoms which arise from the peculiar irritability of the nasal passages in this disease are cough; perversion, abrogation, or complete suspension of the olfactory function; persistent itching, generally referred to the end of the nose; epistaxis; redness of the external integument, with occasional desquamation of the cuticle; sneezing, obstruction, and the discharge of a limpid fluid from one or both nostrils; pain along the bridge of the nose, with occasional tenderness on pressure.

Nasal cough is exceedingly common, is always paroxysmal, and varies in character from a short, explosive, cough-like sound to paroxysms of great violence. In one case under my observation these were so distressing and severe that the patient, a woman, on their approach had to kneel upon the floor and fix the body against some unyielding substance, so great was the convulsive bodily agitation.

The cough is generally short, dry, hacking, or barking* in character, and may be the only symptom for which the patient seeks relief. It is unaccompanied by expectoration, and may be preceded or accompanied by uneasy sensations (prickling, tickling, dryness, sense of foreign body, etc.) referable to the larynx, and generally to the region of the crico-thyroid space. In some persons a distinct laryngeal cough is added to the nasal; that is to say, a double cough is present—a condition which may be described under the title *dibechia.*

Itching at the end of the nose is very commonly a symptom of irritation about the *posterior* portions of the nasal fossæ, and the same may be said of the intense redness of the external nose so frequently symptomatic of nasal affections. The paroxysms of the disease are sometimes terminated by a copious hæmorrhage from the nose, or the latter may be present from the outset of the attack.

Sneezing is a prominent feature. It may occur at any period of the day or night; but most commonly early in the morning, on rising, or in the evening after sunset.

The paroxysms vary greatly in duration and severity, and are brought on by the most trivial circumstances. Getting out of bed, the exposure of the eyes to light, mental impressions, the slightest draught of air, opening a dusty book, and a host of such agencies are alone sufficient to provoke them. In one case they were excited whenever the patient cleaned his teeth; in another the simple act of combing the hair invariably gave rise to attacks of sneezing and tinnitus aurium. In both these cases a cure was effected by removal of the intra-nasal irritability.

A frequent nasal symptom is the copious discharge of a thin, watery fluid, which at times is sufficiently acrid to excoriate the nares and upper lip. It varies greatly in amount; in some instances the patient has to sit for hours over a basin or bucket, into which the discharge literally pours.

Organ of Hearing. The symptoms referable to the organ of hearing are tinnitus, pain in the ear, itching of, and accumulation of wax in, the auditory meatus, sudden stoppage of the Eustachian tubes, redness of the drum-membrane, and clicking and snapping noises in the ear.

In 1883[62] I called attention to certain reflex aural phenomena from nasal disease, to the recognition of which I was led by their accidental production during operative procedures in the nose; and suggested their probable dependence on morbid states of the turbinated bodies, for in certain cases I found that they could be reproduced by artificial stimulation of these structures. Quite recently Dr. C. H. Burnett,[63] of Philadelphia, in an excellent article, describes certain peculiar clicking or snapping noises in or about the ear, which he refers to reflected irritation from the turbinated bones to the muscular tissues of the velum and the superior pharyngeal constrictor and pterygoid muscles, producing clonic spasm. In one instance Dr. Burnett produced the sounds artificially, when the medicated substance was pushed along the inferior turbinated bone into the nasal pharynx.*

Occasionally a peculiar beating noise is heard, apparently upon the drum-membrane, which may possibly be due to spasm of the tensor tympani. The tinnitus which occurs from nasal disease is inconstant, and often dependent upon the condition of the turbinated tissues. Itching of the auditory canal is often a prominent symptom, and the physician is not infrequently consulted on account of this condition alone. If the nasal symptoms are inconspicuous, as they sometimes are, and if nothing wrong is discoverable by physical examination of the ear, the case is liable to be looked upon as one of hysteria, or as the expression of some illy-defined neurosis.

The diagnosis of the reflex nature of these phenomena depends upon the absence of disease of the Eustachian tubes and auditory apparatus, their immediate disappearance with the cure of the nasal affection, and, in some cases, the possibility of their artificial reproduction by irritation of the nasal mucous membrane.

Now and then an enormously swollen and congested condition of the auricles, coming on suddenly and disappearing as rapidly, is observed, which may be regarded

* The so-called hysterical, barking cough of children sometimes finds its explanation in irritation about the nasal cavities which is overlooked by the attendant.

* Clonic spasm of the soft palate, with objective noises in the ear, dependent upon neuralgia of the trigeminus, have since been observed by Schech (Münchner med. Presse, 1886, No. 22, Reprint).

as analogous to the appearance of these structures after section of the sympathetic in the neck. It is sometimes associated with intense itching of the auditory meatus.

Organ of Vision. The congested and, in some instances, inflammatory condition of the conjunctivæ, which is so often observed in connection with nasal disease, is generally explained on the theory of extension of inflammation through the nasal duct; but it is probable that such an event occurs less frequently than is generally supposed, and I am inclined to regard the dilatation of the conjunctival vessels, in a large proportion of cases, as a reflex vaso-motor phenomenon, the vessel-dilatation being kept up by constant irritation of the most sensitive spots in the nasal passages. In the same manner may be explained the recurrent herpes and keratitis which are observed in connection with nasal diseases, the phenomena in these cases being called forth by trophic disturbances.[64] In long-standing cases the conjunctival vessels may become permanently dilated, and even varicose, a condition best seen on eversion of the lids. Added to this there is generally irritation of the Meibomian glands, and a tendency to the collection of yellowish secretion at the inner canthi. Itching in the latter locality is not uncommon. Associated with these symptoms is a more or less constant sense of constriction about the forehead and between the eyes, and a dull feeling, sometimes amounting to pain, in the eyeballs.

During the paroxysm there is increased lachrymation, the eyelids become puffy and œdematous, and even a state of chemosis may develop. Sometimes vision is completely interfered with, and everything becomes blurred before the eyes until the attack passes off. Muscæ volitantes have been not infrequently observed.

I have several times seen a peculiar spasmodic twitching of the eyelids which seemed to depend upon reflected irritation, for it occurred only during the temporary aggravation of the nasal affection. The abnormally hyperæmic condition of the orbital tissues may lead eventually to increased intra-ocular pressure and the consequences dependent thereon.

Organ of Taste. Owing to the close physiological alliance between the senses of taste and smell, morbid conditions of the former are frequent accompaniments of the impeded discharge of the latter function. The reflex neuroses of taste are imperfectly understood; they usually consist in abrogation, perversion, or destruction of the special sense. The perversion of taste is sometimes so great as to interfere with digestion, by creating a distaste for food and the consequent interference with its proper reception by the digestive apparatus.

Pharynx, Larynx, Mouth. Patients suffering from rhinitis sympathetica frequently complain of tingling or itching sensations in various portions of the larynx, pharynx, and roof of the mouth. In the larynx they create a tendency to cough; in the mouth and pharynx there is, in addition, often an irresistible desire to scratch the itching surfaces. Sudden congestion of the oro-pharyngeal and laryngeal membranes is not infrequently observed, alternating sometimes with pronounced pallor of the parts. The engorged conditions of the vessels is occasionally such that rupture occurs, with considerable loss of blood. In a professional colleague the prostration from the hæmorrhage was sufficiently great to confine him to bed for several days.

Marked increase in the amount of the salivary secretion, a swollen, sodden condition of the gums, and herpetic eruptions about the mouth and throat, are also observed in connection with the paroxysms of this class of neuroses.

Lower Respiratory Apparatus; Dyspnœa, Asthma. The dyspnœa which proceeds from reflected nasal irritation varies greatly in degree. At times it is slight, provoking only a faint oppression or consciousness of obstruction to the respiratory forces—a perceptible sense of antagonism between the acts of expiration and inspiration. At others the difficulty in breathing is violent, spasmodic, and, in some instances, apparently dangerous to life. This symptom is one of the most interesting of the phenomena of sympathetic rhinitis.

Dyspnœa may be the result of purely mechanical causes, or, as in the case of sympathetic rhinitis, may be due to reflected irritation from the nose. It is generally supposed that difficulty of respiration from the former cause only occurs when the impediment to breathing is situated in the lower meatus, which latter channel has, by common consent, been invested with the peculiar and exclusive privilege of conducting the air to and from the lower air-passages. It is therefore stated authoritatively that the difficulty of breathing through the nose, which may be termed *nasal dyspnœa*, occurs only when the inferior meatus is in some way or other obstructed. This is in part erroneous, for I now and then see cases in which slight nasal dyspnœa is a prominent symptom, and in which the lower meatus is perfectly free, the obstruction being confined to the upper and middle channels. The cause of the dyspnœa in these cases springs, it seems to me, from a twofold source: (1) From obstruction to the air current; and (2) from disturbance of the physiological relations between the olfactory sense and the respiratory process.

Not infrequently the dyspnœa assumes the form of a distinct asthmatic attack, which comes on, as a rule, suddenly and lasts for a few moments only, or may be prolonged for hours. During the paroxysm the patient presents the characteristic distressing appearances of one suffering from so-called nervous asthma. He breathes with open mouth, and the sibilant and sonorous râles are generally loud enough to be heard without auscultating the chest. The paroxysm, which may be occasionally excited by artificial stimulation of the nasal mucous membrane, passes away gradually, sometimes as suddenly as it came, leaving the patient in a state of great weakness or nervous prostration. The nose is usually filled with a more or less fluid mucus, upon the expulsion of which the paroxysm subsides.

Children are by no means exempt from the asthmatic manifestation; on the contrary, I am inclined to regard it as of frequent occurrence in early life. I have met with well-marked asthmatic paroxysms of the greatest severity in children suffering from this affection at the ages of one month, two years, and five years, and in one case the parents stated that the child had suffered from asthma ever since it was born. In the asthma of childhood the nasal passages should always be systematically and carefully explored, to exclude or determine the presence of any source of reflected irritation.

Especially remarkable is the association of reflex asthma in children with affections of the skin, and notably milk-crust and nettle-rash.

Nervous System. The symptoms referable to the nervous system proper are sufficiently numerous. The most frequent, perhaps, are those which are referable to disturbance in the domain of the fifth nerve, its branches and connections. Of these, the most commonly encountered are supra- and infra-orbital, facial, occipital, and dental neuralgia. Less frequently met with are neuralgic affections of the pharynx, larynx, and neck.

Headache of varying intensity is often associated with swelling of the intra-nasal tissues, and it is not improbable that a certain proportion of the headaches occurring at the menstrual epoch may depend upon the physiological erection of these tissues which is sometimes seen at the monthly period.

It has been known for a long time that convulsions, and even a condition resembling acute hydrocephalus, may every now and then occur in connection with the ordinary nasal inflammation of childhood. The dependence of choreiform attacks and epileptic seizures upon affections of the nasal passages has also been inferred from their complete dissipation with the cure of the nasal disease. I have once seen marked choreic convulsions disappear during the treatment of a nasal catarrh, and it is quite possible that in the cases of epilepsy in which the "aura" starts in the nose it may be connected in some way with structural disease of that organ.

Among the symptoms referable to disturbance of the nervous apparatus may be mentioned cardialgia, attacks resembling angina pectoris, rheumatic pains, itching,

horripilation and formication in various parts of the body, spasm of the laryngeal adductors, of the muscles of the face, neck, etc., and functional and spastic aphonia.

In some cases of long standing the whole nervous apparatus is profoundly involved, and there is scarcely a known neurotic symptom which may not make its appearance at some period or other of the disease.

Exciting Causes of the Paroxysm.—The exciting causes of this form of neurosis are legion. Anything that tends to increase the unnatural hyperæsthesia of the respiratory membrane may provoke an attack (see article on Larynx, Catarrhal Affections of the, in vol. iv.).

My own observations, based on the analysis of a large number of cases, teach (1) that there is practically an infinite number of causes which may precipitate the attack; (2) that one irritant is of itself insufficient to produce the paroxysm, the latter being only possible from abnormal functional activity of the nerve-centres, inherited or acquired; (3) that in the majority of cases the paroxysms are induced by a variety of agencies differing entirely in character and mode of operation, and even in those cases in which there is apparently only one exciting cause it will generally be discovered that there are conditions which bring about the attack other than the alleged solitary exciting cause; (4) that the latter may be operative only during certain periods of the year, or may provoke a paroxysm, without regard to season, whenever applied; (5) that it may be said, in general, that the exciting cause may produce its effect by direct or indirect (reflex) irritation of the sensitive nerves of the nasal and other mucous membranes, through olfactory impression or through simple association of ideas, or the same result may be brought about by physical or mental over-exertion or emotional excitement; (6) that typical paroxysms occur in some persons at any season of the year, from a variety of causes, but especially from sudden changes in the temperature, or from electrical disturbances of the atmosphere; (7) that paroxysms may be produced as reflex phenomena from irritation of a distant organ, or from some excitation starting in the nerve-centres themselves; (8) finally, that pollen is only one of a host of exciting causes, and there is reason to believe that in some cases in which it is supposed to be the excitant it has little or no influence at all.

As an illustration of the effect of a purely psychical impression in the production of the paroxysm, I would call attention to my experiment with an artificial flower, related at the seventh annual meeting of the Laryngological Association,[65] and reported afterward in full in the *American Journal of the Medical Sciences*, January, 1886.

Pathology.—We are at present passing through a revolution of sentiment in regard to the pathology of certain affections whose external phenomena, at least, are chiefly or wholly manifested in the respiratory apparatus, and notably its upper segments. Phenomena inexplicable on commonly accepted beliefs have received their fitting explanation in morbid conditions of these structures, linked to a disordered state—imperfectly defined, it may be—of the vaso-motor sympathetic. Especially is this true of that interesting group of symptoms known as "hay-fever," but for which, I think, the term coryza vasomotoria periodica is a more appropriate appellation.

The various theories advanced in explanation of the nasal reflex neuroses have already been considered, and it remains for me to recapitulate, as briefly as possible, the principal articles of my own belief.

According to my conception, as outlined in several articles published during the last few years, the so-called nasal reflex neuroses, whether taken singly or collectively, as in the case of the *ensemble* of phenomena known as "hay-fever," may be regarded as the protean manifestations of a morbid condition to which I have given the name rhinitis, or coryza sympathetica, and which is characterized by a hyperæsthetic condition of the vaso-motor nerve-centres, linked to a peculiar excitability of the nasal mucous membrane and cavernous tissues. For, if we inquire what condition or conditions are common to them all, what morbid process is capable of producing them, either singly or in combination, and how phenomena apparently so widely different in character and anatomical sphere of operation may be traced to a solitary source, we find the answer in certain more or less clearly defined changes in the nasal apparatus, and in a certain exalted state of the sympathetic nervous system, to which latter we instinctively turn as the organ most conspicuously concerned in the evolution of purely reflex acts. In whatever relation the local nasal affection and the condition of the sympathetic stand to each other in the matter of cause and effect, they must both be regarded as inseparable factors in the production of the phenomena under consideration. It matters not to what hypothesis the path of speculation may lead. Of this we can be reasonably sure, that in order to the production of the characteristic symptoms of this disease a certain excitability of the nasal passages is necessary, plus an exalted state of the central nervous system.

From our present knowledge of the disease falsely called "hay-fever," for example, it seems difficult to escape the conclusion that its pathology is intimately interwoven with a morbid condition of the vaso-motor sympathetic, and probably a hypersensitive state of the nerve-centres themselves. When we recall the fact that in the famous section of the sympathetic in the neck, by Claude Bernard, symptoms similar, or closely allied, to the phenomena of hay-fever were produced; when we reflect upon the results reached by Prevost in his experiments on the spheno-palatine ganglion, is there not a clew to lead us through the labyrinth of our difficulties to a rational solution of the question? Whatever be the essential cause of the disorder, do not its phenomena point directly to a circumscribed disturbance of the vaso-motor sympathetic? What the histological condition of the centres or the nerves themselves may be, is, in the present state of our knowledge, a matter of conjecture; but this much is probable, that their normal impressibility is so increased that when subjected to various forms of stimulation an explosion of nerve-force takes place, which is represented to our senses by certain vaso-motor disturbances in the nasal passages and other portions of the mucous tract dominated by the cervico-occipital sympathetic. The organs which bear the brunt of the attack are the nasal passages, and the exalted condition, erethism of the turbinated corpora cavernosa, is therefore the leading, distinguishing, and characteristic feature of the paroxysm, constituting, as it were, the central symptom, around which the other phenomena of the paroxysm are grouped, and from which many of them proceed, either as the result of mechanical causes or from reflex action. Whatever be the exciting cause of the paroxysm, the tendency to secondary erection of this tissue plays an important rôle in its mechanism, and, just as in an ordinary coryza, the central symptom, the most prominent condition, is represented by the swelling of the cavernous bodies.

For practical purposes, then, we may regard the affection as a coryza dependent upon some derangement of the nerve-centres as its essential cause.

In calling special attention to the irritability of the nasal erectile—or contractile—tissue, I do not by any means seek to overlook the vaso-motor manifestations in other portions of the respiratory apparatus, and even in other organs not directly connected with it. On the contrary, the explosion of vaso-motor force expends itself upon other portions of the tract dominated by the cervico-occipital sympathetic. Just as in a cold in the head we have symptoms referable to the lower respiratory tract, aural apparatus, eye, etc., so in this form of sympathetic coryza we have disturbances in these and other organs of the body. But when the nose is the organ chiefly involved, the symptoms which stand out in conspicuous prominence are those which spring from the erection of the turbinated tissues. That the manifestations included under the head of asthma, cough, congestion of the conjunctiva, etc., may proceed from this source alone, is shown by their immediate dissipation upon the removal of the source of irritation in the nasal passages by topical applications, instrumental interference, or by the artificial contraction of the swollen

tissues. I have been able to illustrate this by the following experiment. In the course of treatment of one of my cases with the cautery I noticed that when the applications were confined to one nostril, the phenomena referable to the corresponding side of the head were completely dissipated, while those of the opposite side persisted and were only removed upon cauterization of the mucous membrane of that side.

While, then, it is probably true that certain states of the nasal passages are necessary to the production of a paroxysm, it is, at the same time, equally demonstrable that these are not always dependent upon well-defined local nasal disease, but that, in a number of cases, such conditions are originally brought about by abnormal excitability of the vaso-motor centres from inherited or acquired disease. The problem, then, presents for consideration two important conditions—on the one hand, the local nasal phenomena, and, on the other, the etiological relations of the central nervous system. In allotting to each its respective causative significance, care should be taken, in avoiding the Scylla of the neurologist, not to be too closely attracted to the Charybdis of another form of specialism.

I am inclined, therefore, to transfer the point of greatest excitability from the peripheral ends of the nerve-filaments to the nerve-centres themselves. While I do not deny the possibility of a hyperæsthetic condition, or even of organic changes in the terminal filaments of the sensitive nerves, as an occasional factor, and while aware of the want of experimental proof in favor of the view advanced, still the theory of a central excitability seems to me to offer a more adequate and comprehensive explanation of the varied phases of the disease. Upon this theory can be best explained, moreover, the occurrence of paroxysms from irritation reflected from various parts of the body remote from the nasal passages. The weight of clinical evidence, too, is in favor of disordered functional activity of the nerve-centres, as against organic alteration of the peripheral sensitive nerves. Finally, it is probably not at the terminal ends of these filaments, but in the centres themselves, that the perception is awakened which differentiates one form of irritant from another; that the nerves themselves are but the passive channels through which the impression is transmitted, and that the production of a paroxysm by a given irritant will depend, other things being equal, upon the, so to speak, discriminating power or peculiar susceptibility of the centres themselves.

In accordance with the views expressed above, I proposed some time ago to substitute, for the various names given to this affection, the term coryza vasomotoria periodica—a term which, while it does not meet all the requirements of a logical definition, may nevertheless be used provisionally until more exact knowledge of this and allied processes furnishes data for the construction of a better.

In assigning to the condition that sets in motion this peculiar group of sympathetic acts, embraced under the common terms "hay-fever" and the "reflex nasal neuroses," the name rhinitis, or coryza sympathetica, as expressive of the two leading pathological factors in its etiology, I believe that the pathway will be opened for the more rational interpretation of this series of nasal neuroses, and the more scientific generalization of their phenomena.

Approaching the problem from this stand-point, and guided by my personal observation, I believe the pathology of the respiratory vaso-motor neuroses may be summed up in the following propositions:

That portion of the respiratory apparatus known as the naso-bronchial tract is, together with its appendages and connections, frequently the seat of certain periodical disturbances, in which paroxysmal explosions of nervous force play a conspicuous part, and which depend, it is reasonable to assume, upon some form of sympathetic or vaso-motor nerve irritation. The vascular changes, with their associated nervous phenomena, may affect the upper respiratory tract in its entirety, either appearing simultaneously or successively in its different segments, or may be chiefly manifested or localized in some individual portion of the tract (nose, pharynx, larynx, bronchial tubes). In the latter case the nasal cavities and the bronchial tubes are most frequently the areas upon which the nervous shock is expended, the two territories being seemingly held in close reciprocal relationship by virtue of a physiological law of sympathy between the two extremities of a mucous tract. In the one case a sympathetic coryza results, in the other a sympathetic bronchitis.*

In the evolution of these reflex phenomena two factors are conspicuously concerned—a depraved condition of the nerve-centres, and an abnormal excitability of certain portions of the naso-bronchial tract.

The derangement of the nervous apparatus may be transmitted from father to son, or it may be acquired in a number of different ways. Thus, for example, it may be the result of prolonged irritation of the respiratory membrane (*e.g.*, from nasal congestion and inflammation, polypi, etc., chronic affections of the larynx, pharynx, and bronchi), leading to repeated and continuous vascular disturbances over certain areas (as, for example, the frequent engorgement of that portion of the nasal cavities covered by erectile tissue), with subsequent abnormal irritation of the nerve-centres.

It thus comes to pass, after a time, that the constant excitation of the nerve-centres by the peripheral irritation so alters their reflex excitability that they respond more readily to reflex-producing impressions. When, therefore, an increase of peripheral irritation occurs, from either extraneous influences or internal causes, a corresponding excitation of the centres is produced, which expresses itself in a paroxysm. We might draw a parallel here between this chain of events and the mechanism of the epileptic attack, or the exaltation of the spinal nervous system from abuse or disease of the generative apparatus.

The exalted state of the centres may be conditioned in another series of cases, entirely independently of any local irritative process in the respiratory tract, by a constant wear and tear of the general nervous system from a multitude of causes—from the faulty nervous constitution which Beard has termed neurasthenia. Such a condition, it is not difficult to imagine, might produce in time a disordered state of the sympathetic and an abnormal functional activity of the vaso-motor centres.

In individuals affected with this form of neurasthenia, local organic irritation would be more likely to lead to reflex phenomena referable to the region of the affected part than in those whose nerve-centres had not been subjected to the same amount of functional strain. In the vaso-motor manifestations under review are found simply an application and illustration of this natural law. Or, to put it in other words, the area in which the vaso-motor reflexes occur will depend, other things being equal, on the seat of the local pathological process—on the localization of the area of peripheral irritability. A polypus in the nose, for example, would excite in such a person symptoms referable to the respiratory system, while a similar growth in the rectum would elicit reflex disturbances referable to the lower bowel. Now, as there is no tract more subject to direct irritation from the external world than the respiratory, we should naturally look to it for manifestations of central vaso-motor disturbance, and herein lies the answer to the question which may be propounded: Why is it that these vaso-motor disturbances are so often encountered in the respiratory tract, and notably in the nasal passages?

In still another class of cases the excessive irritability of the nerve-centres may find its predisposing cause in pathological states of the system as a whole, as, for example, certain diathetic conditions; or it may be the result of reflected irritation from individual parts of the body.

There are certain diseases that tend to abrogate the functional activity of the nerve-centres, and at the same

* Hence we may speak of coryza, pharyngitis, laryngitis sympathetica, and so on, according to the organ in which the vaso-motor phenomena are chiefly manifested.

time show a special proclivity to manifest themselves or leave traces of their existence in the respiratory tract. I might instance gout, rheumatism, certain fevers, syphilis, etc., and it is a clinical fact that the origin of the trouble may be traced to such a source. It is a familiar fact that vaso-motor coryza was, and is by some at present, supposed to be one of the protean manifestations of gout, from the alleged frequency with which it is encountered in those of a gouty diathesis. It is scarcely necessary, however, to point out the inadequacy of this theory, and to lay stress upon the proposition that gout enters as a factor into the etiology of the affection only in so far as it is one of a host of diathetic conditions which lead to weakness of the nerve-centres and inflammatory conditions of the respiratory tract.

I should like to call attention briefly to the occasional remarkable behavior of this group of respiratory neuroses under the influence of certain acute diseases. I have observed the whole group of symptoms—coryza, asthma, sneezing, cough, etc.—completely disappear during an attack of acute rheumatism, while in another case a recurrence of the nasal affection and asthma took place during an attack of measles after a prolonged interregnum of immunity from these conditions.

Let us now consider the hyperæsthetic condition of the respiratory membrane. Is this factor constant, is it primary, is it the *fons et origo* of these affections, or is it fugitive and secondary? Is it the result of purely local disease, or is it the peripheral expression of more central nerve-irritation? These questions have an important practical bearing on the treatment.

The existing confusion in regard to these questions arises from failure to separate the hyperæsthesia naturally associated with the local pathological process and the excessive irritability principally met with during the paroxysms of this class of affection. According to my belief, the intense hyperæsthesia characteristic of the paroxysm is, like the vaso-motor phenomena (engorgement, swelling, etc.) which accompany it, a purely secondary phenomenon, and occurs only through the intervention of central irritation or paresis. This characteristic irritability may pass away with the subsidence of the attack, or may be more or less constantly present in the interregnum, according, presumably, to the amount of structural injury which the nerve-centres have undergone. This secondary hyperæsthesia may be brought about, then, either by a direct impression made upon the terminal nerve-filaments in the respiratory mucous membrane, or by an indirect influence conveyed or reflected through the vaso-motor centres from a distant organ, or, finally, from an excitation starting in the centres themselves.

The hyperæsthesia met with in these conditions may be general, or localized in individual segments of the respiratory tract. In either case, while all portions of the tract, as a whole or in part, may share in the general hyperæsthesia, there are certain areas in which the latter is usually more pronounced, in which a greater susceptibility to the impressions by which reflex acts are produced is discoverable, and in which may be most conveniently and satisfactorily studied the vaso-motor manifestations of this special class of neuroses. These are: In the nasal passages, the area covered by erectile tissue, and chiefly that portion found in the lower and posterior portions of the nostril (posterior end of inferior turbinated body and erectile tissue in the septum immediately opposite—reflex sensitive area); in the pharynx, the vault and posterior wall; in the larynx, the inter-arytenoid commissure; and, in the trachea, certain areas along its posterior wall. It is worthy of notice that, roughly speaking, it is the lower and posterior portions of the individual segments of the respiratory apparatus where these sensitive areas have been shown to exist.

These affections, then, are intimately related to some disturbance of the sympathetic nerve, and probably to a deranged condition of the vaso-motor centres themselves.[66] The neurasthenic phenomena, whatever the condition may be upon which they depend, may, as has been pointed out above, be due entirely to a primary irritation or well-defined disease in the nostril or in other parts of the respiratory tract; but until this condition is produced the case is simply one of ordinary nasal inflammation, and does not become true vaso-motor coryza until the nervous apparatus is markedly involved. In other words, we are dealing with a neurosis, or, at least, with an affection, in which the neurotic element plays the essential and most conspicuous part.

In support of this view I desire to call attention to the existence of a hitherto undescribed neurosis of the aural apparatus closely allied, or analogous in etiology, mechanism, etc., to vaso-motor coryza. Suffice it to say here that in this affection we have to deal with, if we may thus express it, a sort of hay-fever of the ear. When to this we add the recent observation of Dr. Gradle * concerning a periodical affection of the conjunctiva closely analogous to hay-fever, we have, it seems to me, additional evidence in favor of the sympathetic origin of the affection under review. In vaso-motor coryza the area over which the reflex vaso-motor disturbances are manifested is chiefly the territory which receives its vaso-motor nerve-supply from the spheno-palatine ganglion; in the aural neurosis the phenomena are localized or more pronounced in the area presided over by the otic; in Dr. Gradle's cases of recurring conjunctivitis the parts involved are supplied by the ophthalmic, and so on.

I would also refer to two additional observations which I have made, and which are of especial interest in view of the probable vaso-motor or sympathetic nature of the affection—viz., the occasional marked swelling of the thyroid gland, and to an enormously swollen and congested condition of the auricles analogous to that of the rabbit's ear in the famous experiment of Claude Bernard upon the cervical sympathetic.

I have said, above, that the two areas most frequently and notably concerned in these respiratory vaso-motor disturbances are the nasal passages and bronchial tubes. This leads me to refer briefly to the question of asthma and its relation to nasal disease.

The older writers, as has already been pointed out,[67] were doubtless familiar with the disease known as "hay-fever," which they considered as a species of, or identical with, the so-called bronchial asthma of the present day.

It was not until after the observations of Bostock that the asthma arising from the emanations of grasses was regarded as distinct from the asthma produced by other causes, while it has taken nearly a century for us to return to the simpler classification of the older nosologists. Even now our notions of the condition known as "asthma" are more or less vague and indeterminate. It is looked upon as a disease *per se*, as a distinct pathological entity; but if we consider exactly what is involved in the ordinary conception of this condition—that, like many other disturbances of respiration, it has no definite anatomical lesion, that it is common to an almost indefinite number of pathological states—we shall be forced to regard asthma as a symptom which, like cough, may be ushered in, follow, or occur simultaneously with irritation in various parts of the body, but which is most commonly symptomatic of some disorder of the respiratory tract. I do not propose to discuss the mechanism of the asthmatic paroxysm; whether the bronchial constriction be essentially a spasmodic phenomenon, or whether it be due to an engorged condition of the mucous membrane analogous to that seen in vaso-motor coryza—a transferrence, so to speak, of the nasal swelling to the bronchial tubes—are matters which do not come within the range of the present inquiry.

While there are many reasons for belief in the correctness of the latter view, which was advanced by Weber,[68] and which has recently found an eloquent defender in

* Am. Jour. of the Med. Sci., April, 1886. Morill Wyman (Autumnal Catarrh, p. 20, New York, 1876) had before called attention to a certain conjunctivitis which is met with in June, which resisted ordinary treatment, and which he suspected owed its origin to a cause similar to that of "June cold."

Sir Andrew Clark,* and while such transferrence probably does take place in a large number of cases, still it were unwise, in the present state of our knowledge to eliminate completely the element of spasm as a possible factor in other cases, and to lay down the law that the constriction of the bronchial tubes alleged to be peculiar to this condition can only be brought about by sudden swelling of the mucous membrane.

An interesting feature of a certain proportion of the class of cases we are now discussing is the occasional association of urticaria, asthma, and coryza. The relation of asthma to skin affections was familiar long before the days of Trousseau. Thus the illustrious Hoffmann † mentions, as a fact of common experience, that asthma sometimes follows the suppression of a cutaneous rash; and before him Baglivi ‡ had recommended, in such an event, that the patient should sleep with one having the "scabies," that, catching it, he might be relieved of his asthma. It is also related that William of Orange was cured of an inveterate asthma during the running of a sore on the shoulder produced by the famous cannon-ball wound received at the battle of the Boyne.

The coryza may precede the asthma and urticaria in time of appearance, disappearing or remaining after their eruption; or the asthma or urticaria may antedate the attack of coryza; or, finally, instead of alternating the one with the other, they may appear simultaneously in the individual. At the Eighth Annual Meeting of the American Laryngological Association I stated my belief that these phenomena seemingly depend on an imperfectly defined neurosis or vaso-motor influence (possibly some derangement of the cervico-occipital sympathetic), which is probably the connecting link between these affections. Now, in attempting to define the reciprocal relationship between this triad of conditions, we may regard the skin essentially as a part of the respiratory tract—as the external organ of respiration. To justify this assumption, it is only necessary to recall the physiological importance of the skin in respiration among some of the lower animals, and the embarrassment of respiration in man from pathological or experimental suppression of the cutaneous function. We may accordingly regard this neuro-vascular disturbance of the external surface as a natural symptom of the respiratory vaso-motor neuroses, and assume that, while the relation of asthma and coryza may be explicable by a possible normal sympathy existing between the two extremities of the internal respiratory tract, both asthma and coryza may be linked to the skin affection by a sympathetic bond which holds in equilibrium and close consent the whole mechanism of the respiratory function.

Complications and Sequels.—The disease may lead to various structural changes, usually of an inflammatory nature, in the respiratory tract; or may induce a general depression of the nervous apparatus, with derangement of the bodily health; and its effect on the mental faculties may even lead to a condition of melancholia. I have known congestion of the lungs and extensive emphysema to occur in cases in which asthma is a prominent symptom. In one instance the termination of the asthmatic paroxysm was accompanied by a peculiar disturbance of the circulation in the extremities. The fingers and toes became purplish-black and cold—almost gangrenous—from localized arrest of the circulation, and at times the arms and legs were covered with small circumscribed areas resembling the spots of purpura. Occasionally the auricles become enormously swollen and congested, and the thyroid gland is distended and surcharged with blood. Various localized vaso-motor disturbances are also observed in other parts of the body. Thus I have known sudden reddening, accompanied by itching and burning sensations and a slightly swollen condition, confined to the fingers of one hand, to occur, and pass away at once with the subsidence of the paroxysm. In one patient—a boy, ten years of age—the application of medicines to the nasal mucous membrane invariably brought out an eruption resembling urticaria on the neck and chest, which necessitated a discontinuance of topical medication. In children, especially, eczema and tinea capitis not infrequently complicate the case, and seem to be directly related to the nasal disease through the nervous apparatus. In one child a vesicular eruption came and disappeared with the advent and subsidence of the nasal symptoms. Indeed, the skin seems to be unusually vulnerable and sensitive. Profuse sweating sometimes occurs, which may involve the general surface or be confined to individual portions of the head and neck—the parts most frequently affected being the forehead and cheeks.

The so-called "erysipelas" of the face, chiefly manifested on the cheeks and nose, may perhaps be regarded simply as a reflex vascular disturbance directly referable to central irritation or paresis, and comparable to an accentuation of the act of blushing.

Diagnosis.—Whether a special sensitiveness in certain portions of the nasal mucous membrane exists or not, the agitation of the question has led to more rational methods of procedure in the treatment of a large class of nasal affections, and to more conservative methods in intra-nasal surgery. Before the location of the sensitive area or areas, the nasal tissues were destroyed with an almost ruthless recklessness.

The localization of the sensitive areas has not only greatly facilitated the treatment of this class of disease, but has also furnished us with what is often a ready means of diagnosis. In a fair proportion of cases it is possible to reproduce the attacks of cough, asthma, etc., by artificial stimulation of the nasal mucous membrane, either by means of a probe or similar contrivance, or by the electric current. Before coming to a decided opinion, other accessible portions of the respiratory tract should be systematically tested; for, as has been seen in the section on Pathology, there may be a number of sensitive points along the whole respiratory system and pharynx, whose irritation may awaken the reflex. If it be not possible to produce the reflex by stimulation of the mucous membrane, the diagnosis must be made by exclusion, and from the absence of disease in the regions in which the reflex symptoms are manifested of sufficient magnitude to cause the disturbance. At the same time it should be remembered that in long-standing cases structural changes of considerable importance take place, which may lead to confusion of cause and effect. The local use of menthol [69] and cocaine, as a rule, temporarily dissipate the reflex symptoms, and may be regarded, within proper limits, as valuable adjuvants to diagnosis.

Finally, the amelioration or cure of the reflex disorder by local applications to the nasal passages will demonstrate the nature of the trouble.

Prognosis.—In regard to prognosis I can only repeat * that it will depend, not only upon (1) the nature of the predisposing and exciting causes, and the facility with which they can be removed, but also (2) upon the amount of structural injury done to the respiratory apparatus, (3) to the central nervous system, and (4) to other parts of the body included in the arc of the reflex, neuro-vascular, and motor disturbance.

I have found children, as a rule, more amenable to treatment than adults, although the severest types of the

* American Journal of the Med. Sciences, January, 1886. In simple justice to Trousseau, whom some recent writers seem to overlook, it must be stated that he was the first to look upon the peculiar coryza (undoubtedly the hay fever of the present day) occurring in connection with asthma (see above) as one of the manifestations of that disease, as a part of the asthmatic process; and also the first to suppose that the difficulty in respiration sometimes associated with urticaria was "occasioned by an eruptive or congestive state of the mucous membrane of the bronchial tubes analogous to the eruption and congestion on the skin" (op. cit., vol. ii., p. 284).

† "*Ita experientia docemur, a scabie retropulsa . . . a tinea capitis male curata . . . insignem pituitosam exoriri.*" F. Hoffmann, Op. omnia physico-medica, part ii., § ix., p. 257, Genevæ, 1760. In speaking, too, of the symptoms of asthma, he adds, "Mucus per nares excluditur."

‡ Opera omnia med. practica, ed. octava, Lugduni, 1714, Prax. med., appendix de asthmate, p. 104. "*Et scabie retropulsa si asthma fiat, cum scabioso dormiendum est, at scabies revocetur, vel urticis cedenda cutis.*"

* See my former publications.

disease often occur at an early period of life; and in the management of this class I have been, almost without exception, successful.

Each case has its peculiarities and difficulties, and must be studied on its individual merits. It is therefore difficult to lay down any definite law which will apply in all instances. I believe, however, that with our advancing knowledge of the respiratory neuroses, and with a proper conception of these cases in all their bearings, the prognosis, in general, may be written down as good. If the above principles be faithfully carried out, relief can always be secured, and in a fair proportion of cases a permanent cure may be effected.

Treatment.—In the management of this form of neurosis we should at the outset carefully distinguish between two sets of cases, viz.—(1) those in which the nervous system is just beginning to suffer; and (2) those in which it is more markedly involved, or in which it is the starting-point of the neuro-vascular disturbances. To illustrate: A patient with disease of the nose, either well-marked or unsuspected, suffers from paroxysms of cough, becomes asthmatic, or is troubled with some other symptom referable to reflex agency or some other so-called "reflex neurosis." There are no other appreciable signs of a disordered nervous organization. Perhaps this is the sole symptom for which he seeks relief. He is otherwise in apparently excellent health. Examination of the nasal fossæ is made, with the discovery of a congested or catarrhal condition of the mucous membrane, a nasal polypus, or a deflected septum; and upon the removal of the local affection the asthmatic paroxysms cease, or the cough subsides, and the patient is restored to apparent health without the administration of constitutional agents.

Now, what is the explanation of this curious relationship? When we consider the fact that hundreds of this patient's neighbors suffer from precisely the same nasal affections, and that only a comparatively small proportion of them are affected with similar reflex troubles, there seems to be no escape from the assumption of an abnormally excitable nervous apparatus and its constant irritation by the pathological condition in the nose.

As the irritation produced by worms, or morsels of undigested food retained for a long time in the gastro-intestinal canal, sometimes gives rise to convulsions, cough, and other reflex disturbances through the constant irritation of the readily impressionable nerve-centres of the infant, so the prolonged excitation of the hypersensitive nerve-centres of the sufferer by the local pathological process may evoke the reflex disturbances which are under consideration. The cause of the convulsion is not the worm or the undigested particle of food, but the prolonged action of a local irritant upon a naturally excitable nervous organization. So in the hypothetical case which has been just considered. It is manifestly unwarrantable to assume that there is anything in a nasal polypus, an hypertrophied membrane, or a deflected septum to cause asthma and allied nervous disorders; but, in the absence of more definite knowledge, it is reasonable to infer that such an event or events probably occur through the intervention of a more central cause. The explanation suggests itself that, in this particular case, the nasal passages may be the sole avenues through which the nerve-centres are influenced; and with the removal of the irritant, and their consequent physiological rest, the disorder has been apparently, and, in the course of time, may be actually, dissipated.

Let us follow this individual a little farther on in his life-history. Perhaps the relation of his paroxysmal cough to the nasal affection has been unrecognized. In a little time asthma is added to his disease; later on, affections of the eye, ear, and other organs, with various other symptoms referable to a disordered state of the general nervous apparatus, develop. He has no longer one troublesome reflex symptom, but a dozen; he consults his physician, and if it be in the summer-time, is told he has "hay fever," and that pollen is responsible for his trouble.

I have called this an hypothetical case. It is not. It is the accurate record of clinical fact. It is the historical narrative of *one* way in which the nervous system may be affected in the sympathetic affections of the respiratory tract.

The first thing to determine, then, in a given case of nasal reflex neurosis, is to ascertain whether the nervous phenomena be due primarily to respiratory irritation, to central causes, or to disease in remote organs of the body; whether the symptoms referable to the respiratory tract be primary or secondary, and if primary, to what extent the nervous system is involved. The class of cases in which relief and cure may be expected from local remedies alone is that in which the respiratory membrane is the primary seat of the disease, and in which the nervous system has not become markedly involved. In this set of cases, or, to look at the subject from another stand-point, at this *stage* of the disease, are included a number of the simple forms of nasal reflex neuroses. At this stage the removal of a nasal polypus may cure a troublesome asthma or cough, the cauterization of the nasal mucous membrane may dissipate an inveterate hemicrania, and so on. Even at the later stage, when the group of symptoms commonly known as "hay-fever" develop, it may be possible, by securing physiological rest for the nerve-centres, to give temporary and even permanent relief. But when the central nervous apparatus becomes more profoundly impressed, when nearly every organ of the body seems to be included within the arc of the neuro-vascular disturbance, when permanent structural changes occur in different parts of the respiratory and other systems, it is manifestly unnatural to expect that the disorder may be dissipated by the touch of the galvano-cautery, as the evil spirit disappears before the magician's wand.

The principles involved in the foregoing propositions have served as the basis and rules of my practice in this class of affections during the past four years, and with a most gratifying result. In that time a large number of cases of paroxysmal vaso-motor neuroses of the respiratory tract have come directly or indirectly under my professional observation. Of this number the nasal passages were most frequently the seat of the vascular disturbance, and next in frequency the bronchial tubes and pharynx. Occasionally the affection was more or less clearly localized in the laryngeal cavity, but, according to my experience, this is an exceptional event. While the sympathetic nerve-disturbances manifest themselves most frequently in the nasal cavities, in a certain proportion of cases the pharynx and larynx appear to be the starting-point of the trouble, and I have traced a number of reflex phenomena, such as asthma, cough, etc., to diseased conditions of these structures. The vaso-motor disturbances, of both the pharynx and larynx, are, however, commonly associated with, or preceded by, similar affections of the nasal cavities. In the pharynx and larynx they are characterized by an excessive degree of hyperæsthesia, the very act of opening the mouth giving rise in some cases to retching, and even vomiting. Indeed, a considerable number of cases of so-called hyperæsthesia and paræsthesia of the larynx and pharynx are traceable to some vaso-motor disturbance or sympathetic nerve-irritation. The changes in the vascularity of the mucous membrane often take place with great rapidity, the vessel-dilatation being quickly replaced by a condition approaching pallor, while the latter as quickly gives place to the laryngeal or pharyngeal blush. In cases in which the neurotic feature is especially well marked, the alternate dilatation and contraction of the vessels can be most conveniently studied. The suffusion and swelling may be diffuse and uniformly distributed over the structures, or it may be more pronounced over certain areas, presenting a certain anatomical resemblance to a cutaneous eruption.

The secretion of colorless watery fluid is not so constant nor so abundant as in analogous conditions of the nasal passages, nor is the swelling of the mucous surfaces so conspicuous. The reflex phenomena symptomatic of this class of pharyngo-laryngeal neuroses need not detain us at present. Suffice it to say that they are sufficiently nu-

merous, and consist chiefly of various sensory and motor disturbances in the path of the nerves that radiate from the pharyngeal plexus, and in spasmodic contraction of the pharyngo-laryngeal muscles. In one case the spasm of the pharyngeal and palatal muscles was so great that it materially hindered the passage of air through the nares and laryngeal vestibule, causing the patient to start suddenly from his sleep with what might be termed a veritable naso-pharyngeal asthma.

In whatever portion of the respiratory tract these vaso-motor neuroses are situated, the general principles of treatment are in each and every case essentially the same.

When, some time ago,[70] I formulated the view according to which the so-called nasal or respiratory reflex neuroses—the group of phenomena known as "hay-fever," "asthma," and other reflex conditions found in connection with nasal disease—may be classed as symptoms which, owing their origin to a common cause, form part and parcel of a single pathological process, I did so not merely upon theoretical grounds, but based my conclusions upon the results of clinical experience, upon the observation that the treatment of one of these neuroses was essentially the treatment for all; and whether we have to deal with paroxysmal cough, asthma, or with the *ensemble* of those phenomena known as "hay-fever," "rose cold," etc., the therapeutic indications are identical.

With these brief prefatory remarks let us turn to the most typical and interesting of these affections, in which the nasal passages and adjacent organs are the most conspicuous seats of the vascular disturbances, and which we may designate coryza vasomotoria periodica.

The chief indications in the treatment of this affection are: (1) To remove any existing local respiratory disease or irritation; (2) to so alter the nutrition of the nerve-centres that they may not respond so easily to reflex-producing impressions; (3) to search carefully for any pathological condition, systemic or local, which may be regarded as a source of direct or indirect irritation of the nervous or respiratory apparatus, and adopt appropriate measures for its relief; failing in the above measures, (4) the partial or complete destruction of the vessels or sinuses over the area or areas in which the vascular disturbance is most marked.

The first lesson to be learned in the treatment of this affection is that it is a chronic neurosis, and, as such, requires chronic treatment. It should be remembered that the peculiar condition of the sympathetic is, like epilepsy, with the patient by day and by night, in winter and summer, ready at any moment, under favorable conditions, to give expression to its presence by a paroxysm. Any treatment, therefore, undertaken a short while before the expected attack, or during its course, is almost wholly palliative, and can rarely, if ever, accomplish any permanent good. And thus the innumerable remedies (such as chloral, belladonna, opium, stramonium, etc.) which have been used from time to time can accomplish no lasting good, and in many cases either lose their beneficial effects altogether, or, in the end, by their constant physiological effects upon the nerve-centres, may tend even to aggravate the predisposition to the affection. In this category I would place cocaine. As I pointed out some time ago,[71] and also at the seventh annual meeting of the Laryngological Association,[72] the long-continued use of this drug in the nose and throat begets an increased irritability of these structures, due, probably, to the repeated contraction and consequent fatigue of the contractile elements in the smaller vessels and erectile tissues, which terminates in some cases in a subparalytic condition of these structures, and subsequent puffiness of the membrane. As the habitual use of cathartics eventuates, sooner or later, in constipation, so the prolonged use of cocaine will result, in a certain proportion of cases, in a hyperæsthetic condition of the mucous membrane. In the case of the erectile tissues it is especially open to the objection that, by bringing repeatedly into play the contractile power of these structures, it may ultimately weaken their walls and lay the foundation for a permanent dilatation of the erectile cells. In calling attention to these disadvantages of its continuous use in these affections, I do not by any means desire to question the many excellent virtues of this remedy. In certain acute affections of the mucous membrane, and for its effect on the nasal erectile structures, pointed out by Bosworth, it is a Godsend, but I am convinced that at present it is too indiscriminately and injudiciously employed. In the disease under review, it has in my hands utterly failed to dissipate, except temporarily, its symptoms, or to abridge, in the slightest degree, its course. For a short while amelioration is secured, but at the expiration of a period varying from half an hour to two hours the symptoms recur, and the drug has to be used again and again.

My custom is to treat this affection as I would any other chronic disease of the nervous system. The commencement of the treatment, accordingly, should date from the first appearance of the patient for consultation, and terminate, it may be, long after he is apparently free from his disease. I cannot insist too strongly on the importance of prolonged and continuous tonic treatment addressed to the nervous apparatus. It may at first fail, and the paroxysms return again and again with all their accustomed severity; but if it be persisted in, the time will come, sooner or later—provided there is not some incurable lesion—when the intervals between the paroxysms will be longer, and the attacks themselves less severe, until finally they cease altogether.

The great mistake which is universally made, it seems to me, is the suspension of treatment upon the termination of the attack, and I therefore wish to emphasize the importance and necessity of continuous treatment throughout the interregnum of fancied immunity from the disease.

In carrying out this remedial course two difficulties will present themselves: The firmly rooted belief in the patient's mind that there is nothing the matter with him in the intervals of exemption; and his natural discouragement when, in spite of treatment, he may have an occasional return of his old disorder.

The general tonic and hygienic treatment will vary with the individual peculiarities of the subject and the conditions of his environment, and will usually consist, to speak in general terms, of prophylactic measures directed against the development of nervous and catarrhal affections.

Among the many remedies I have tried in the constitutional management of this class of affections, I would mention and recommend arsenic, phosphorus, zinc, quinine, and nux vomica. These drugs may be used alone or in combination for an almost indefinite time, if the usual precautions in regard to their physiological effects are exercised. The following method of administration, although it has failed me at times, has nevertheless been so generally beneficial in my practice that I do not hesitate to recommend it for trial:

(1)

℞. Zinc. phosphid. . . . . gr. $\frac{1}{6}$
Quin. sulph. . . . . gr. ij.
Ext. nuc. vom. . . . . gr. $\frac{1}{2}$
M. Ft. pil. no. j.
Sig.: To be taken before meals.

(2)

℞. Liq. arsenic. et hydrarg. iodid., gtt. iij. ad v.
Sig.: In a wineglassful of water, after meals.

Formerly I used Fowler's solution, but for the past year have substituted the iodide of arsenic and mercury (Donovan's). The quantity of the ingredients should be increased according to the judgment of the physician. Should the physiological effects of any of the remedies manifest themselves, it should be stopped for a week or so, and then resumed in the same or diminished doses.

I may add, in leaving the subject of constitutional treatment, that for several years I have employed the above-mentioned lines of treatment in simple inflammatory conditions of the nasal passages and throat, and have

found them important auxiliaries, especially in the earlier stages of the simple inflammatory process, when the vaso-motor element of inflammation is chiefly evident from the repeated and sudden erection of the turbinated structures.[73]

I have also seen good effects from the continuous use of the bromides and the iodide of potassium. In two cases I have made use of the constant current (from ten to fifteen cells), placing one electrode over the nape of the neck, and passing the other extremity of the current alternately over the region of the superior cervical ganglion and through the nasal passages. In one, apparent, and in the other decided, relief to the symptoms was obtained. Although my experience with this agent has not been sufficient to warrant me in pronouncing either for or against its use, I consider it, nevertheless, worthy of further trial.

In one case a satisfactory result, as far as the amelioration of the symptoms was concerned, was secured by partial obliteration of the pharyngeal vessels with the galvano-cautery. The patient, a physician, suffered from the pharyngeal variety of vaso-motor neurosis, associated with an abnormally large, swollen, and varicose condition of the veins on the posterior wall. The vessels were cut across in a number of places, and since the operation the paroxysms have been notably less severe.

In regard to the topical treatment of existing nasal disease, I can only repeat what I have said over and over again, that any treatment addressed to the nasal chambers accomplishes one result, and one only—it closes one door against *ab extra* irritation of the nerve-centres. In many cases, it is true, this will be of itself sufficient. The nasal passages may be the sole avenues through which the nerve-centres are influenced, and, with the removal of the irritant and the consequent physiological rest of the centres, the disorder may be apparently, and in the course of time actually, dissipated. But there are other cases in which, from what I have indicated above, such a course will obviously fail.

In order to the intelligent appreciation of the local or topical management of this affection, the principles which underlie the etiology and mechanism of the paroxysms should be considered.

It should be borne in mind, in the first place, that the hyperæsthesia of the mucous membrane and the excitability of the turbinated nasal tissue are secondary phenomena, dependent, as a rule, upon a direct impression made upon the sensitive nerves of the mucous membrane and upon the terminal filaments of the olfactory; upon an indirect influence conveyed or reflected through the vaso-motor centres from a distant organ; or, finally, upon some excitation starting in the centres themselves. This stimulation of the nerve-centres, from whatever cause originating, is reflected outward, probably through the sympathetic filaments which reach the turbinated structures with the spheno-palatine nerves.

Now, as these nerves are distributed over the posterior and inferior portions of the nasal fossæ (sensitive reflex area), the turgescence of the erectile substance is more noticeable over that particular area; and it will be found that this surface represents the most sensitive spot to reflex-producing expression—at least this is my experience.

If, then, we destroy the terminal filaments of the sensitive nerves, it follows that one avenue at least is closed against the irritative action on the nerve-centres of substances derived from the external world. My practice, therefore, is to simply sear the most sensitive portions of the membrane, as determined by experiment with a probe, with the flat cautery-knife, taking care to include only that portion in the operation which has been found most sensitive to irritation. I have found this procedure alone sufficient to arrest the paroxysms and give prolonged immunity from them.

In order to exclude completely the influence of *ab extra* irritation, it is necessary to remove all sources of local irritation, from whatever cause arising. If this be radically done, it will put a stop to the production of paroxysms from external influences acting directly on the nasal mucous membrane—that is all. When paroxysms are induced by agencies operating within the organism, or from reflected irritation from other parts of the body, the destruction of the sensitive nerve ending in the nasal mucous membrane will obviously be insufficient to secure immunity from further attacks. The indication here is to search carefully for any such source or cause of irritation, and to direct treatment accordingly.

In the destruction of the vessels and sinuses over the most sensitive areas, the surgeon should proceed with caution, taking care to destroy as little tissue as is compatible with the radical removal of the disease. In the large majority of cases extensive destruction of the cavernous tissue is neither necessary nor advisable. Total extirpation of the corpora cavernosa is a practical impossibility. Even if practicable, it would be warrantable only as a last and desperate resource. The amount of tissue to be sacrificed must be determined by the exigencies of each particular case. Having determined the area or areas of special reflex excitability, the nerves of the mucous membrane and cavernous structures may be destroyed by an acid (chromic, glacial acetic, nitric, etc.), or extirpated with the cold-wire snare or cautery.*

In this country and in Germany, where the surgical treatment of nasal neuroses had its origin, the operators invariably start out with the idea of *extirpation* of the cavernous tissues. To that end large portions of the offending bodies are removed *en masse* with the cautery-loop, or allowed to slough off after numerous incisions and punctures with the knife-electrode. I have rarely found such procedures necessary, and believe that I accomplish an equally good, if not better, result by operating on a somewhat different principle. Having mapped out the area of most pronounced vascular disturbance, I make a stellate incision through the mucous membrane and cavernous body with the cautery-knife. The vessels in the pathway of the incision become thereby obliterated, a star-shaped cicatrix results, resembling somewhat a syphilitic scar, and the mucous membrane and turbinated tissue become, so to speak, bound down or depressed upon the bony wall of the nostril. In order to avoid extensive sloughing, the incisions may be made at different sittings. By means of this method a sufficient patency of the nostril is secured, the erection of the turbinated bodies is brought under control, and the patient escapes with a comparatively small loss of function.

In answer to the question as to whether the operation should be performed during the so-called "season," or whether it were better to wait for the interregnum of immunity from the attacks, I would answer that there is nothing to be gained by delaying radical treatment, and it has therefore always been my custom to operate in the interval between the paroxysms. By this means I have succeeded in preventing their return, even when the individual has been exposed to the exciting causes of the attack.

If the theory upon which I base my plan of treatment be accepted, it will readily be seen that those who consider the removal of nasal obstruction or irritation as the sole remedy for this disorder base their belief upon an incomplete conception of its pathology.

The value of the galvano-cautery and other therapeutic measures addressed to the nasal passages will depend, to a large extent, upon whether the existing nasal disease is the primary cause of the central irritation, whether it is the sequel of repeated attacks of vaso-motor coryza, or whether it is a purely accidental phenomenon. Whether primary, secondary, or accidental, it always acts as an

* In regard to the operative measures to be used in a given case of hypertrophic inflammation of the nasal passages, the following are my rules of practice:

1st. Posterior hypertrophic enlargements of the turbinated bodies are most satisfactorily removed, if practicable, with the cold-wire snare.

2d. For destruction of anterior hypertrophic swelling, both of the turbinated bodies and septum, and in the rare cases when operation is necessary on the enlarged erectile bodies of the posterior portion of the septum, the galvano-cautery is the most available and satisfactory agent.

3d. Extensive destruction of cavernous tissue is most satisfactorily accomplished by means of the galvano-cautery or electrolytic process.

excitant of the disease, and it is of the utmost importance that it should receive the most careful attention. But it must not be forgotten, at the same time, that behind the nasal, throat, and head phenomena stands the neurosis, and that, until the sympathetic nerve irritation is overcome, we cannot expect to thoroughly eradicate the disease.

ADDENDUM.—[1] L'Union Medicale for January 22, 1884, La Lyon Medical, M. Lange, before the Medical Society of Lyons, on the existence of a hyperæsthetic area (tache cérébrale) on the posterior end of the inferior turbinated bone and adjacent parts of the septum, which he considers as a special organ of sensation, which he compares to the "cystero atrophique" of Zuckerkandl connected with the vessels as Loewe's gland. Professor Rendu, of Paris, Revue de Laryngologie, d'Otologie, etc., December 15, 1885, in a case of epistaxis in the general acceptance of the fact that the posterior end of the inferior turbinated bodies are the seat of a sensitive area claimed with particular precision the points that, according to his experience, are not the only ones to be found on the posterior portion of the septum, but a more extensive area on the nasal, viz.: the posterior part of the septum. Professor Bonafous thus believes that the sensitive area is represented by only a circumscribed portion of the area located by me in 1884. Dr. Hering, of Warsaw, on the other hand, confirms my statements (Congrès de Genève du même, etc., Lyon, 1886, with the same title as mine, Sept.). "While many authors call into question the existence of the sensitive area of Mackenzie, my experience justifies me in a full agreement with a certain portion of it. I believe that it must be made to correspond the [illegible] segment of the mucous membrane which covers the nasal septum, and not come the posterior part, as claimed by Mackenzie."

Finally, I would call attention to some exceedingly interesting experiments made by Dr. L. Lechtwitz, at the Hospital of Saint Andre, in Bordeaux, under the direction of Professor Pitres (see Revue mensuelle de laryngologie, etc., décembre, 1886): Les zones hystérogènes observées sur la muqueuse des voies aériennes supérieures et des organes des sens. Without going at length into the important experiments of Lechtwitz, suffice it to say that in all the six cases (hysterical and hystero-epileptic) experimented upon, the nasal fossæ were the seat of "spasmogenic" zones. Six times they were bilateral, once they existed only on one side, while, in the other side there was found a "hypnogenic" area. The spasmogenic areas were found in the posterior portions of both nasal fossæ: touching them provoked the crisis. The right area seemed to be more sensitive than the left.

John Noland Mackenzie.

[1] Ueber eine operative Radical Behandlung bestimmter Formen von Migraine, Asthma, Heuheber, etc. Wiesbaden, 1884

[2] Medical Times and Gazette, August 13, 1864

[3] British Medical Journal, April 30, 1864

I am indebted for these references to Spencer Watson's work on Diseases of the Nose.

[4] Ogle: Am. Journal of the Med. Sciences, vol. xxiii., 1852.

[5] Medical and Chirurgical Transactions, 1876, vol. lii.

[6] Plato: Symposium, § 13.

[7] Aph. 13. Compare also Celsus, lib. ii., cap. 8.

[8] Opera omnia græco latin., vol. iv. Problem xxxiii., 2 and 8. Parisiis, 1858. Ed. Didot.

[9] Op. omnia, Venet., 1608, lib. iii., Fen. 5, tract. 2, cap. 14

[10] Opera medica., Basilæ (date uncertain; 1544 or 1450. Lib. S. G. Oribasii Divisionum, lib. i., cap. 43.

[11] Op. cit., Ad. mansor. de re med., lib. ix.

[12] Ibid., cap. xiii.

[13] Fragment ex Aphor. Rabi Moyses. Good: Study of Medicine, Boston ed., 1823, vol. i., p. 311

[14] Trans. Med. Chir. Fac., 1885; Am. Journal of the Med. Sciences, Jan., 1886.

[15] N. Y. Medical Journal, February 26, 1887.

[16] Dissertat. inger vertigine laborans. Jenæ, 1682. Diss. de vertigine. Jenæ, 1707 and 1741.

[17] Bergeron: Thèse d'agrégation, 1872, referred to by Louis Villemsens. Thesede Paris, No. 494, 1872. Etude sur le cat. spasmodique d'été, etc.

[18] In op. infra citat., spec. lib. i., cap. x., p. 342 et seq.

[19] Georg. Gottlieb Gumprecht: Diss. de consensu partium præcipuo pathologico et praxeos medicæ fundamento. Halæ-Magdeburgicæ, 1717.

[20] Cerebri anatome cui accessit nervorum descriptio et usus. Amstelodami, 1666, interad. cap. 21, 25, 26, and 27.

[21] Neurographia universalis. Lugduni, 1685, lib. iii., caput v., de nervis intercostalibus, eorumque nimis.

[22] De sympathia seu consen. part. corp. humani, ac potissimum ventriculi, in statu morboso, diss. medica. Harlemi, 1721.

[23] Observationes medico practicæ de affectibus capitis internis et externis. Scaphusii, 1728

[24] Diss. de consensu part. corp. humani. Gott., 1749; also in Haller's Collect. dissertat. pract., vol. vi., No. 220

[25] De sympathia et causis morborum. Epist. xiv., 28.

[26] Op. cit., xxvii., 281.

[27] Prælectiones academicæ de morbis nervorum, etc. Lugd. Bat., 1761, tom. ii., p. 885

[28] Historiarum anatomic. et medic. rariorum., cent. v. et vi., ed. Haffniæ, 1761, v., p. 184.

[29] Observations on the Nature, Causes, and Cure of those Diseases which have been commonly called Nervous, Hypochondriac, and Hysteric. Second edition. Edinburgh, 1765, p. 125.

[30] Œuvres. Lausanne, 1788, vol. ix. Traité des Nerfs et de leurs Maladies. A Genève, 1785, chap. xxii. De la Migraine, p. 105.

[31] Op. cit., p. 169.

[32] Darwin, Charles: Experiments establishing a criterion between mucous humors and purulent matter

[33] Christian Gottfried Gruner: Physiologische u. pathologische Zeichenlehre, etc. Jena, 1801, p. 122.

[34] Op. cit., p. 377

[35] William Heberden: Commentaries on the History and Cure of Diseases. London, 1802; also published in Latin, chap. ci., p. 172.

[36] Op. cit., chap. 21, p. 125, 126.

[37] Traité des mal. des fosses nasales, etc. Paris, 1804.

[38] Lehrbuch der Augen- und Ohren-Heilkunde, etc., S. 249, 312. Wien, 1871

[39] Berl. klin. Wochenschrift, 1874, No. 19, S. 503

[40] N. Y. Medical Record, October 11, 1879

[41] Deutsche med. Wochenschrift, 1879, p. 573.

[42] Lond., 1859, Nos. 32 and 33; Lab. 12, p. 425, and 1882

[43] Meeting of Am. Laryngological Assoc., 1880. See Archives of Laryngology, April, 1881, p. 147

[44] Quoted by Power and Tweedy

[45] Trans. of the Missouri State Medical Assoc., 1881.

[46] Berliner klin. Wochenschrift, 1881, 16, 17.

[47] St. Louis Med. and Surg. Journal, February, 1882.

[48] Archives of Laryngology, April, 1882, p. 112

[49] Lond., p. 118.

[50] Gazette des Hopitaux, 1882, No. 56, 13 mai.

[51] Lond., No. 61, 3 juin.

[52] Verhandlungen und neue Vorträge, No. 216, 1882.

[53] Archives of Laryngology, April 1, 1882.

[54] N. Y. Medical Journal, May 12 and 19, 1883.

[55] Quoted by Hack, op. cit.

[56] A Contribution to the Study of Coryza Vasomotoria Periodica, etc., N. Y. Med. Record, July 19, 1884. Trans. Amer. Lar. Assoc., 1884, p. 113. Coryza Vasomotoria Periodica in the Negro, etc., N. Y. Med. Record, October 18, 1884. Reflexive Sympathetic. Maryland Med. Journal, April 11, 1885. Origin and Cure of Coryza Vasomotoria, etc. Trans. Med. Chir. Faculty of Maryland, 1885. Location of the Seat of Disease in Asthma. Journal of the Medical Sciences, October, 1885, pp. 511-528. Production of Rose Cold by an Attack of Rose, etc., Med., January, 1886, etc.

[57] Autumnal Catarrh, Hay Fever. New York, 1876.

[58] Hay Fever, etc. New York, 1876.

[59] N. Y. Med. Record, October 18, 1884.

[60] Trans. Am. Laryngological Assoc., June 24, 1885, p. 26 et seq.

[61] See my paper in Am. Journal of the Med. Sciences, July, 1882.

[62] Trans. Medico Chirurgical Faculty of Maryland, 1885; Trans. Am. Laryngological Association, 1885. Trans. Virginia State Society, 1883.

[63] Trans. of the American Otological Society, 1884, p. 270. Reprint.

[64] See Trans. Med. Chir. Fac. of Maryland, 1885.

[65] See Transactions, 1885, pp. 31, 32

[66] For an elaboration on this point, see, especially, Am. Journal of the Med. Sci., October, 1885, loc. cit.

[67] Trans. of the Med. Chir. Fac. of Md., loc. cit.; Am. Journal of the Med. Sci., January, 1886

[68] Ueber Asthma nervosum. See Tageblatt d. 45 Versammlung deutsch. Naturforscher u. Aerzte in Leipzig, 1872, p. 159.

[69] A. Rosenberg: Berliner klinische Wochenschrift, 1885, No. 48.

[70] Maryland Med. Journal, April 11, 1885

[71] Discussion on Cocaine, May 15, 1885. Trans. of the Med.-Chir. Fac. of Maryland, 1885, p. 189.

[72] Discussion, June 26, 1885. Trans. of the Am. Laryngol. Assoc., 1885, p. 142. I may add that since then Beverley Robinson (Med. Record, October 17, 1885, Ingals (Journal of the Am. Med. Assoc., February 20, 1886), and others have recorded similar observations.

[73] See article by the writer in the Medical News, Philadelphia, April 4, 1885

NOSE, TUMORS OF THE. Neoplasms of the nose may be of a benign or of a malignant nature. It may be said of them, in general, that all varieties ordinarily found in other organs or upon other parts of the body may be found in the nasal fossæ. Some forms, however, are so rare as to be little more than pathological curiosities. Of benign growths the variety most commonly met with is the simple myxoma, or so-called mucous polypus. More rarely are found the adenoma, angioma, or erectile tumor, papilloma, enchondroma, and osteoma. There have also been found growths composed of some of the elements of a dermoid cyst, and, somewhat analogous to these formations, a hitherto nameless variety presenting a structure similar in its elements and in their arrangement to the helix of the ear. The latter, springing from the inferior aspect of the retro-nasal space, generally in the vicinity of the floor of the nose and the soft palate, are more properly classed as growths of the pharynx.

I.—Benign Tumors.

Nasal Polypi; Mucous Polypi; Myxomata.—The term nasal polypus should, properly speaking, refer to any tumor of the nasal passages. By derivation and by general consent, however, it is understood to describe (as defined by Mackenzie) a new formation, generally of the nature of a myxoma, but sometimes containing a small amount of fibro-cellular tissue; it is usually pedunculated, and round, oval, or pyriform in shape, of pale pinkish color, semi-transparent, and varying in size from a currant to an acorn, but occasionally larger, giving rise to more or less obstruction of the nasal passages, with its associated symptoms. The slight resemblance in external appearance which it bears to certain low forms of marine life has probably suggested its name.

The ideas advanced by the older writers as to the causation of polypi, namely, that they are due to such influences as heredity, struma, etc., have not been proved by more recent observations; that they may arise from mechanical irritation is more probable.

In fact, it must be confessed that the causes of nasal polypus are as yet unknown. Mere chronic inflammation is not sufficient to produce it, since among the very large number of cases of chronic catarrh comparatively few patients are found to have this trouble. Zuckerkandl found it in every eight or nine autopsies. Men are more liable to the affection than women; the proportion in two hundred cases studied by Morell Mackenzie being one hundred and twenty-three men to seventy-seven women. The youngest case in which the writer has met with this condition was in a boy, aged thirteen, and one case is on record in which it occurred in a boy aged twelve.

Mackenzie gives the following table, showing the age and sex of two hundred patients with nasal polypus. The table indicates as nearly as possible the age at which the growths commenced:

Age.	Male.	Female.
16 to 20 years	9	7
20 to 30 years	51	34
30 to 40 years	33	13
40 to 50 years	18	13
50 to 60 years	9	10
60 to 70 years	3	0
	123	77

The earliest symptoms of this condition are such as would attend an ordinary coryza. There is, generally, marked susceptibility to taking cold. The attacks of coryza increase in frequency and in severity. Owing to the hygroscopic quality of the polypoid tissue, the growths tend to increase in size during an attack of coryza, and in wet weather, so that at such times they cause a greater degree of occlusion than when in their ordinary condition. Later, headache is a common symptom, and this is occasionally associated with disturbance of the mental processes. If left to themselves, their growth continues until complete occlusion of the affected nasal passage results. The discharge is of an ordinary and simple character. Epistaxis sometimes occurs. The olfactory sense, as will be readily understood from the anatomy of the parts, is either blunted or destroyed, by reason of the growths offering a mechanical obstacle to the entrance of the inspired air, and with it the odorous particles, to the olfactory region. Taste is also more or less impaired, while the nasal canal and the Eustachian tube may be obstructed.

Mackenzie gives the following table showing the apparent situation of 259 polypi observed by him in 200 patients, the growths having been bilateral 59 times.

Middle turbinated body	104
Neighborhood of superior turbinated body and superior meatus	77
Middle turbinated body and middle meatus	34
Middle meatus	24
Inferior turbinated body	9
Whole of outer wall of nose (except inferior meatus)	11
	259

The septum is rarely the site of the affection, but seven such cases having been reported.

The nasal polypi usually remain within the nasal cavity, and rarely grow beyond the nostril, though sometimes they extend backward to and into the pharynx, and occasionally have been found involving the sinuses. They sometimes become adherent at several different points to the adjacent walls of the nares, so that the location of the site of the pedicle becomes a matter of difficulty. Mucous polypi are generally multiple, although it occasionally happens that a single large growth will be found; when, however, one such growth has been removed, it will almost always be possible to discover others still existing. In shape they are generally pedunculated, owing to the attraction of gravitation acting upon their semi-fluid contents. As they grow larger, however, they are forced to adapt themselves to the contour of the surrounding cavity. They may also be found of rounder shape, with broad base and entire absence of pedicle. Zuckerkandl believes that the pear-shaped variety arise from sharp edges, while those with broad bases occur upon flat surfaces. Their size varies greatly. It is not uncommon to find two or three large ones associated with a large number of very small ones in the same nostril. Their color is generally of a translucent pearly grayish white, more rarely pinkish, and now and then, in the case of an old and well-organized specimen, of a dull yellowish, opaque color. The surface is smooth and shiny, and when the tumors are touched they are felt to be elastic. They themselves are devoid of sensibility, although the mucous membrane in their neighborhood may be in a highly sensitive state.

Within the last few years extensive studies have been made with regard to the reflex influences of nasal polypi, and, although their importance may by some writers have been overestimated, it is a matter of common clinical observation that marked reflex symptoms may follow their presence. Thus, asthma has not infrequently been cured by their removal, while reflex cough, hemicrania, and supra-orbital neuralgia, vertigo, and even epilepsy have been attributed to them, and chronic coryza and hay fever are often due to their presence. In the matter of diagnosis little difficulty generally exists. Their appearance is characteristic, while their softness, elasticity, and freedom from pain render them unlike any other growth likely to be met with. They also differ from growths of a more serious nature in that they do not bleed easily upon being touched, and rarely cause disfigurement. Deviation of the septum can hardly be mistaken for them, if both sides of the septum be carefully examined, nor can hypertrophy of the mucous membrane covering the septum, if cocaine be applied to it.

Abscess of the septum and other growths of this part of the nose can be differentiated from polypi by the appearances present, and from the fact that polypi so rarely spring from this locality. The greatest difficulty likely to occur is in distinguishing polypi from hypertrophy of the mucous membrane covering the middle or lower turbinated bodies. The easiest mode of differentiation is by the application of cocaine. Under the influence of this, hypertrophied mucous membrane will at once become retracted, while, when the drug is applied to the polypi, no apparent effect is produced.

The external investment of mucous polypi is composed of ciliated epithelium, beneath which there are generally a few dilated capillaries, but no nerves. The bulk of the growth is made up of embryonic connective tissue, consisting of a hyaline gelatinous material, through which more resisting cellular trabeculæ pass in various directions. The gelatinous substance is very rich in mucin, and contains in the early state round and oval cells which, at a later period, become elongated, fusiform, or stellate, and for the most part nucleated and granular. The latter kind of cell is said to be most common. The consistency of the growth depends upon the greater or less degree in which the connective-tissue stroma or the mucous substance predominates in its structure. Here and there small cavities, full of a colorless, stringy fluid, may be met with, which some regard as true cysts. Again, true cysts have been observed in the neighborhood of polypoid growths. As to the exact site of origin of nasal polypi, Zuckerkandl has given some interesting observations derived from the study of 42 different growths; of these, 14 grew from the edges of the hiatus semilunaris, 3 from the edges of the hiatus and the infundibulum, 2 entirely from within the infundibulum, 1 from the ostium frontale, 1 from the ostium sphenoidale, 1 from the ostium ethmoidale, 2 from the antrum, 10 from the middle meatus, 3 from the upper meatus, 4 from the middle, and 1 from the upper turbinated body.

The presence of mucous polypi is seldom attended with danger, although they may give rise to serious local and reflex irritation. After removal they manifest a decided tendency to recur, owing, no doubt, to lack of thoroughness on the part of the operator in removing the whole of the larger growths, and also to the probable presence of smaller growths, which, being re-

lieved from the pressure of their larger companions, increase rapidly in size. Moreover, there seems, in the case of certain individuals, a tendency to recurrence which can only be explained on the ground of a special susceptibility, and which may become a source of serious annoyance, if not of positive danger.

Spontaneous expulsion of a polypus sometimes takes place. In the treatment of nasal polypi astringents have been used from time immemorial. They can be of little service, however, except to relieve temporarily the more annoying symptoms produced through irritation of the adjacent mucous membrane by the polypi themselves. The injection into the substance of a polyp of various escharotics has been practised, with, however, questionable success. Thus chromic, acetic, and carbolic acid have been employed, and each has had its advocates.

The surgical measures for the removal of nasal polypi are three in number, viz., evulsion, abscission, and the galvano-cautery. Of these, evulsion with the forceps is by far the oldest, and the one still most generally practised. The success which attends its employment will be due entirely to the operator's knowledge of the anatomy of the nasal chambers in general, and of the precise location of the growths to be attacked. The old-fashioned method of setting blindly to work with a pair of polypus forceps and tearing away whatever might come into the grasp of the instrument without knowing what tissue had been seized, cannot be too strongly reprehended. The result of such careless operating is, necessarily, the infliction of severe and unnecessary pain, the production of copious hæmorrhage, the possible serious injury of healthy parts, and the imperfect removal of the growths. In all cases the polyp should be removed with the aid of the rhinoscopic speculum or mirror, care being taken not to work in the dark. No one instrument is likely to meet the necessities of every case, so that a variety of forceps is desirable. In using forceps, the pedicle of the polypus should, if possible, be grasped, and the growth removed as near to the mucous membrane as possible. It is well not to attempt to remove too many at one sitting, for, although the operation may be accomplished with comparative thoroughness at one time, it is impossible to do wholly satisfactory work when the parts are obscured by blood. When working with a clear light and with the growths in full view, it is comparatively easy to detect their attachments, and, besides, the patient is thereby saved much pain.

The application of cocaine to the nasal mucous membrane is of the greatest service, not only in rendering it nonsensitive, but in causing it to retract, and in thus bringing the growths into plainer view. In practising evulsion, the growths should be seized, the blades of the forceps firmly compressed, and the handle of the instrument moved up and down and slightly twisted to one side. For the abscission of nasal polypi, the best instrument to-day is a light, small-sized Jarvis écraseur. With this the pedunculated growths may be removed easily, without hæmorrhage, and with a minimum of pain. It is particularly useful in cases of growths originating far back in the nasal passages. It is highly desirable that the evulsion or abscission of the polypi should be followed by some plan of treatment calculated to destroy thoroughly any remaining polypoid tissue. For this purpose application to the site of the polypi of some escharotic or powerful absorbent will be found of advantage. The best of these is undoubtedly the galvano-cautery. Strong solutions of iodine, chromic acid, or carbolic acid, may be used for this purpose. Care should be taken, however, to confine them absolutely to the parts desired. The galvano-cautery itself affords an excellent means for the removal of polypoid growths, and in some respects this is superior to any other method. It causes, on the whole, less pain, and by a majority of patients it is preferred. The chief objection to its use is that a number of applications are usually required to secure entire removal of the myxomatous tissue. Something may be accomplished in preventing the development of nasal polypi by relieving the chronic inflammations of the nasal mucous membrane which are favorable to their development.

In studying the prognosis of nasal myxoma, there is presented a question of great interest to the pathologist and of great importance to the patient, namely, is the simple histological structure of the growth ever transformed into one of a more malignant type? This question, denied many years ago by Billroth, has of late received confirmatory evidence in the hands of Michel, Hopmann, Schmiegelow, Max Schaeffer, and Bayer. The latter reports a case in which a carcinomatous area was discovered within a large mucous polypus. Cases are not wanting, too, in which, after the repeated removal of polypi, the nasal mucous membrane has assumed a condition of irritation which, to say the least, is slow to subside, and which renders it, in all respects, a fertile soil for the production of new-growths of a less benign nature. Indeed, there are many cases in which it is difficult, if not impossible, to distinguish between simple hypertrophies of the mucous membrane and veritable neoplasms. The truth of this will be better realized in observing the changes which may have taken place in the vicinity of a growth the malignant nature of which cannot be questioned.

Adenomata.—These growths consist in an hypertrophy of the glands of the mucous membrane. They would be harmless, were it not for the tendency which they display to undergo epitheliomatous degeneration. The tumor at first bears a decided resemblance to a mucous polyp. It is, however, of firmer consistency, approaching somewhat that of an enchondroma. Its progress is slow as long as degeneration has not begun. When this becomes established, however, the course is that of an ordinary epithelioma. In the period of transition the differential diagnosis can be made only by the use of the microscope. Whichever may be the nature of the growth, the treatment must be surgical.

Angiomata.—Angiomatous growths of the nose are rare. A careful study of the subject was made by Dr. John O. Roe, and published in the "Transactions of the American Laryngological Association" for 1885. By including in his list all growths in which the vascular element predominated, such as erectile tumors or nævi, vascular tumors, angioma cavernosum, and the fibro-angiomata, there were found the records of but thirteen cases, and to these Dr. Roe has added one. In analyzing them it was found that in two instances the tumors were attached to the cartilaginous septum, while the others, as far as the origin was designated, grew from the upper parts of the nasal fossæ, as, for instance, from the vomer, the basilar apophysis, the inferior surface of the body of the sphenoid, and the vault. In but two cases were the middle turbinated bodies involved. In but one instance was the growth located in the right naris, while in no case has it been reported as growing in both, either at the same time or alternately. From the structure of the inferior turbinated bodies it would be natural to expect to find them the site of the above neoplasms. That this is not the case will be seen from the above analysis. A study of the tabulated report of Dr. Roe gives also the following statistics: Of the 14 cases but 2 were women. The oldest case was sixty-eight years of age, the youngest thirteen. In 8 cases the patient was under twenty.

The duration is uncertain, several cases having suffered from epistaxis since childhood, while in one case a tumor of unusual proportions developed within six weeks.

Of the symptoms reported, epistaxis is by far the most common and well marked. Indeed, it was present in every case and the attacks were generally profuse and persistent.

Five of the 14 patients died, 4 of them as the direct result of operation. Of these 1 was operated upon by Nélaton's method; 1 by resection of the superior maxilla; 1 by removal with the curette through an opening made in the side of the nose; 1 by an attempted removal with forceps. Four cases are now recorded in which removal was effected by means of Jarvis's cold-wire écraseur. The success attending this method is most gratifying. In operating with it great deliberation can be used, and thus even less hæmorrhage is produced than when the

galvano-cautery is used, so that the operation may be considered as entirely safe. Its superiority over the more severe surgical measures employed in the four cases mentioned above, in which death occurred, is obvious. In using the cold wire it will be desirable to have a galvano-cautery at hand, so that, should the removal of the tumor be only partial and hæmorrhage ensue, the remnant of the growth may be thoroughly obliterated, and thus the best prospect for the relief of the bleeding secured.

Papillomata.—The exact nature of the so-called papillomatous tumors of the nose appears to be a matter of considerable doubt.

Hopmann claims that in a collection of 100 cases of growths of the nasal cavities he found 14 papillomas. Zuckerkandl, on the other hand, states that he has met with but one. Three others, however, which he refers to as polypoid excrescences, seem to bear a close similarity to the true papilloma. The first-mentioned writer describes two pathological varieties, namely, epithelial papilloma or benign cauliflower excrescence, and soft papilloma, the latter being subdivided into adenoma, angioma, fibro-sarcoma, and fibro-sarcoma papillare, according to the predominance of gland-structure, vessels, areolar tissue, or proliferating cells.

Morell Mackenzie states that he has met with but 5 undoubted examples of intra-nasal papilloma. In no instance was the growth larger that a split pea, and in 4 of the cases there were at the same time mucous polypi in the nasal fossæ.

From the classification of Hopmann, quoted above, it would appear that there is nothing in particular to distinguish these neoplasms from other growths of the category corresponding to the subdivision which he has made. As long as a growth can be classed as an adenoma, or an angioma, or a fibro-sarcoma, the division papilloma seems not only unnecessary but even calculated to produce confusion.

Osteomata.—These are bony tumors of the nose; they are covered by the nasal mucous membrane, are generally of dense structure, but sometimes cancellous, and are not connected with the osseous framework of the nose. Their size varies greatly, and they may attain large dimensions, and thus cause serious destruction to the neighboring parts. The affection is rare, and is most often encountered in the young. That these tumors are the result of any diathesis is improbable. Specific treatment has no effect in checking their progress. The causative influence of traumatism is more apparent, particularly in the injuries to the nose, so common to young children.

Most of the patients observed have been about twenty years of age. Sex seems to make no difference. The early symptoms are obscure, and the patient seldom seeks relief until the growth has attained considerable size.

Those which may be present at first, however, are coryza, epistaxis, and a marked sensation of itching. As the tumor enlarges there is more or less obstruction to nasal respiration, loss of the olfactory sense, and often neuralgic pain of severe character, due, no doubt, to pressure upon nerve-filaments, which becomes worse as the growth increases in size. Anterior rhinoscopic examination reveals a tumor covered with mucous membrane, sometimes of a rose-red color, sometimes dark red, or even purplish. Later there is ulceration, and even necrosis may be present. There is usually at this time a fetid discharge, resembling that from syphilitic disease of the nose. Meanwhile the parts upon which the growth encroaches may be eroded or else forced from their normal positions, and thus distinct deformity, both external as well as internal, may be produced. Neuralgia may give place to anæsthesia as the irritated nerves become more forcibly compressed.

Pathologically the structure of these growths does not differ from osteomata in general, a description of which will be found in the article Osteoma.

Of the two varieties, the ivory and cancellous, the former is the more common. Tumors of this class are sometimes so dense as to resist the strongest surgical forceps. Their peculiar consistence is easily determined, the point of a needle pushed through the mucous membrane being quickly arrested. In the tumors of the cancellous variety, however, this is not uniformly the case.

Their size is variable, ranging from that of a bean to growths of very large proportions. Their form differs, also, and depends upon their size and age. They are seldom actually attached to the osseous surface with which they are in immediate relation, and when a pedicle does exist it is generally small. Their separation from the underlying bony structure is usually easy.

Left to themselves, nasal osteomata increased in size until they fill the nasal fossæ, encroach upon the pharynx, the maxillary sinus, the orbital cavities and the base of the skull, and, finally, give rise to grave cerebral complications. In other cases they may cause serious symptoms from caries, necrosis, and suppuration. They are usually diagnosed and removed before these accidents have taken place, and show little tendency to recur after extirpation. The prognosis is generally good, provided the growth can be removed through the natural passages.

In the earlier stages the diagnosis may be somewhat difficult, the growth being readily mistaken for an exostosis or a nasal calculus. Osteomata, during the early part of their course, are generally somewhat movable, while, of course, an exostosis is not. A calculus is of more friable consistency, as may be demonstrated by exploring the surface of the obstruction with a long needle. Enlargement of the turbinated bodies might be diagnosed by an inexperienced observer. This error is more liable to occur in the case of the middle turbinated bodies, since they are so commonly asymmetrical. The tissues covering the turbinated bones, however, are soft, lax, and yielding, and quite unlike the tense investment of an osteoma. No other nasal neoplasm is likely to cause as much neuralgia excepting cancer, while the growth of the latter is far more rapid. Fibrous tumors of the nose are very rare.

The only treatment is extirpation. The cancellous osteoma can be crushed with strong forceps and removed in fragments. In the case of ivory-like growths it has generally been considered necessary to lay open the nose, preferably, if possible, by Rouge's operation, which consists in separation of the upper lip and base of the nose from the superior maxillary bone, and reflecting them upward over the face, so that the anterior nares are brought into immediate view. Should this not give sufficient space, some other and more radical surgical procedure is advised. To the great credit of American surgery be it said, that in this country such dangerous methods have been superseded by the use of the burr of the dental engine. By means of this instrument in skilful hands the most difficult cases have been successfully treated, the growths being removed through the natural passages, with a minimum of shock to the patient, with none of the after-dangers of a capital operation, and with absolutely no disfigurement to the external parts.

Enchondromata.—Cartilaginous tumors of the nose are so rare that hardly a dozen cases are on record. The growth is incident to youth, all patients thus far observed having been under eighteen years of age. In a case successfully operated upon by the writer, and already reported by him, the patient was but two and a half years old.

The symptoms, in general, are those of nasal obstruction. The tumor is never pedunculated. It usually springs from the cartilaginous septum, or, rarely, from the outer wall or roof of the nose.

The prognosis is good. Recurrence does not take place, and there can be little excuse for removing the growth by any but the natural passages. The diagnosis may be made from the position of the growth, its method of implantation, its consistence, which is readily determined by means of a fine exploring needle, and its insensibility. It need never be mistaken for a deflection of the septum, since when this exists there is a corresponding depression on the opposite side. Removal, in most instances, may be accomplished with little difficulty by means of the knife, the cold snare, or the galvano-caustic loop.

Exostoses.—Exostoses of the nasal fossæ, other than those mentioned under the head of bony ridges or spurs of the septum in the article on congenital and acquired malformations of the nose, must be very rare. Indeed, in the study of many thousands of fairly well-preserved skulls the writer has been unable to find a single well-marked instance. The same methods of treatment would apply to them as to the cases of osteomata referred to above, at least, when they are situated upon the septum.

Dermoid or Embryonal Cysts.—Of the nature of these growths are certain abnormalities which have been observed occasionally in the nasal fossæ. They may consist partly or altogether of hair, or they may contain cartilage, bone, fat, connective tissue, and glandular substance. The presence of teeth in the nose has been observed in several instances, and seems to be the most common accident of this class.

Osseous Cysts.—Several cases have been reported in which this condition was present in the nasal fossæ. According to Bayer the cysts originate sometimes in the bony tissue itself, sometimes between the bone and the periosteum. These growths may be either unilocular or multilocular. They are generally crossed by lamellæ of bone which incompletely divide them, and they are often surrounded by a bony ridge, due to chronic inflammation of the periosteum. They are apt to originate upon the septum, or upon the inferior turbinated bone. Their symptoms are analogous to those of an osteoma, and their progress slow, but progressive. The treatment applicable in these cases is either the radical extirpation of the cyst, or incision and destruction by the aid of the galvano-cautery. If the cyst be multilocular each division must be opened in turn, and this treatment must be continued until the growth has disappeared.

In addition to the tumors above described echinococcus cysts and herniæ cerebri have been met with in the nasal fossæ.

II.—Malignant Tumors.

Malignant tumors of the nasal fossæ, of primary origin, are rare. In this situation, as in other parts of the body, their etiology is obscure, although it is possible that long-continued and unusual irritation of the nasal mucous membrane may be a factor in their production. With the exception of sarcomata they occur more commonly after middle life. Sarcomata, however, have been found in very young children. Of the cases seen by the writer, during the past fifteen years, a majority have been in males, although the experience of other observers has been to the contrary.

Sarcomas are said to arise most frequently from the septum. They might easily be mistaken for enchondromas, were the latter not distinguished by symptoms which are pathognomonic. They are apt to develop rapidly, and to extend to the various cavities in their vicinity, causing much destruction to the surrounding parts, and consequent deformity. The symptoms generally present are obstruction of the affected nasal cavity, followed later by epistaxis, and the secretion of a sanious, fetid, muco-purulent discharge; respiration is, of course, impeded, the quality of the voice is changed, and the olfactory sense is impaired. Neuralgia is a marked and distressing symptom. It may attack one or both sides of the head, and it generally increases in severity until the nerves pressed upon by the growth are paralyzed. Upon examination, the tumor, in the earlier stages, is seen to be simply red, and perhaps nodulated; later it becomes ulcerated, grayish in color, and covered with an unhealthy secretion. It bleeds at the slightest touch.

Epitheliomatous tumors may be distinguished from simple myxomata by the fact that they are more red, that their surfaces are highly vascular, and that they bleed readily. These symptoms render the diagnosis tolerably easy; while the presence of a single growth, its rapid development, the destruction which it carries to the surrounding parts, and the other well-marked symptoms of pain, discharge, epistaxis, and general cachexia, will place the question beyond the possibility of doubt. As to the diagnosis of malignant growths of the nose in general, their early recognition is often exceedingly difficult. It is, at the same time, most necessary, for upon it will depend, in great measure, the prognosis. Although it has been stated that the septum is the most common site of malignant tumors of the nose, this, in the experience of the writer has not been the case, nor does there seem any reason, histologically, why it should be so, since the other structures of the nasal fossæ are more vascular, and, probably, subject to greater irritations. Rhinoliths and foreign bodies may generally be detected by examination with a probe. The question of syphilis, although not easily eliminated by inspection, may be settled by placing the patient upon specific treatment and observing the result. The ulceration of lupus is nearly always attended with external manifestations of that disease. Great rapidity of growth, especially of the tumor which has returned after removal, is characteristic of sarcoma. Microscopic examination of a part of the growth is generally possible, and should always be made.

The prognosis, as in the case of cancerous disease in other parts of the body, is grave. Growths of the sarcomatous variety seem to be of a less malignant nature than the others, and with them the prognosis is not absolutely bad. Morell Mackenzie reports a case in which a myeloid sarcoma was removed from the nasal septum, in a man aged sixty, in whom seven years after the operation there were no signs of recurrence. In a case of melanotic sarcoma, removed three years ago by Dr. R. P. Lincoln, of New York, in the presence of the writer, from the middle turbinated body and outer wall of the right nasal fossa of a lady aged about thirty, the patient has remained well up to the present time.

All of the older authorities agree that the only proper method for the treatment of malignant growths of the nose is thorough and radical extirpation, and they generally recommend that in order to render the operation a success, the growth be fully presented to the vision of the operator by means of a preliminary operation. This, however, with the improved methods and instruments used for operations upon the nasal cavity at present is by no means necessary in a large number of cases. In the case of melano-sarcoma, quoted above, the operation was performed through the natural passages by means of the galvano-cautery, and with absolutely no mutilation of the external parts. In a case of ordinary sarcoma, observed by the writer, decided arrest of the growth seemed to follow injections into its tissue of lactic acid, twenty minims of a thirty per cent. solution being used. Another palliative measure is the persistent application to the surface of the tumor of an astringent solution, while attacks of hæmorrhage may generally be controlled by the use of the galvano-cautery. *D. Bryson Delavan.*

NOTOCHORD. The notochord (*chorda dorsalis*, *Wirbelsaite*) is a rod of peculiar tissue, constituting the primitive axial skeleton of vertebrates. It begins immediately behind the pituitary body (hypophysis), and extends to the caudal extremity. It occurs as a permanent structure in the lower types, and as a temporary one in the embryos of amphibia and amniota, including man. Comparative embryology has shown that it is a greatly modified epithelial tube, which arises as a furrow in the median dorsal line of the entoderm, being in position and mode of development analogous to the ectodermal medullary canal, or primitive tubular nervous system.

Development in Mammals.—The notochord appears very early in the course of development, its differentiation from the entoderm begins at the time when the medullary groove is not fully marked out posteriorly, and is nowhere closed. The notochordal *Anlage* can be first detected in the entoderm just at the front of the primitive streak, as an axial band of cells, which at first in mammals is not well marked off from the mesoderm: as the medullary groove deepens it pushes down toward the mid gut until it comes into actual contact with the notochordal epithelial band (see vol. iii., p. 174, Fig. 1240), thus dividing the mesoderm into two lateral masses: this also leads to the temporary transverse stretching of the

notochordal band, which thereby loses for a while its sharp demarcation. It soon re-acquires it, and becomes considerably thicker (Fig. 2513, *nch*) than the adjoining entoderm, and forms a distinct though shallow groove. Subsequently the band separates off, and the entoderm proper closes across under it so that the notochordal band lies between the entoderm and the floor of the medullary groove (or later canal), as shown in Figs. 2514 and 2517, *nch*. (Compare also vol. iii., Figs. 1241, 1242, 1244, and

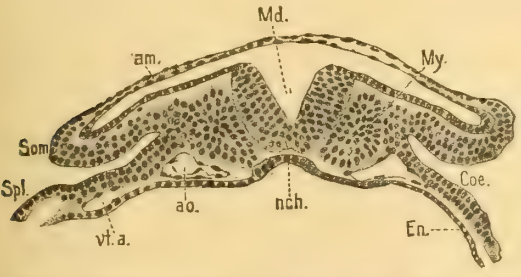

FIG. 2513.—Transverse Section of an Embryo Mole, Stage H. (After Heape.) *am.*, Amnion; *md.*, medullary groove; *my.*, myotome; *coe.*, coelom or body cavity; *en.*, entoderm; *nch.*, notochord; *ao.*, aorta; *vt.a.*, vitelline artery; *som.*, somatic mesoderm; *spl.*, splanchnic mesoderm.

1246.) This separation does not take place at the anterior extremity of the chorda until somewhat later, so that for a considerable period its front end remains fused with the walls of the mid-gut (Fig. 2514). The separation from the entoderm is effected, at least in mammals, by the entoderm proper, showing itself under the notochord toward the median line, and when the cells from one side meet those of the other, they unite with them and form a continuous sheet of entoderm below the notochordal cells.

The chorda is now a narrow band of cells, starting anteriorly from the wall of the alimentary tract and running backward to the blastoporic canal or its equivalent the primitive streak; but, at the period when the canal is open, the chorda terminates in the entodermic epithelium lining the canal (Heape,[8] Pl. xxi., Fig. 50; compare also vol. i., Fig. 427 C). The canal remains open for a time, and is called by some writers on mammalian embryology the chorda-canal (*cf. infra*). For a certain period the chorda continues growing tailward by accretions of cells from the walls of the blastoporic passage, and after the

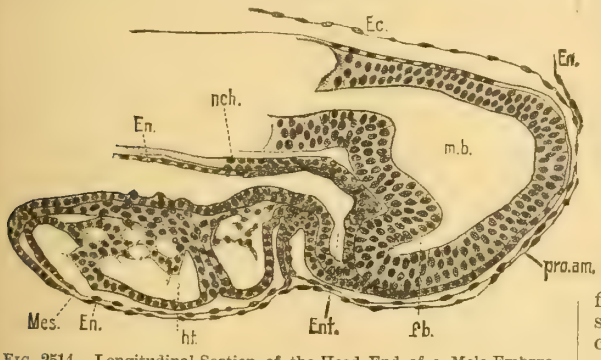

FIG. 2514.—Longitudinal Section of the Head End of a Mole Embryo, Stage H. (After Heape.) *Ec.*, ectoderm; *en.*, entoderm; *pro.am.*, proamnion; *mb.*, mid-brain; *fb.*, fore-brain; *ent.*, entodermic cavity; *ht.*, heart; *mes.*, mesoderm; *nch.*, notochord.

canal is permanently obliterated the chorda may still continue its lengthening by acquisitions at its caudal end of additional cells from the primitive streak; such cells may, however, properly be regarded as coming from the entodermic lining of the blastopore. We can, then, distinguish three portions of the notochord; the first arising from the entoderm of the mid-gut; the second from the entoderm of the blastoporic canal; the third presumably from the entoderm of the obliterated blastopore in the primitive streak. Braun and others have sought to attribute essential importance to these differences, but, it seems to me, improperly. It is more reasonable to say that the chorda arises in the amniota, as in the lower forms, directly from the entoderm, but presents certain secondary modifications in its development.

Lieberkühn[17] has directed attention to a special peculiarity in the early development of the notochord in mammals. There appears at first a passage—half canal, half furrow—which extends nearly the whole length of the primitive streak; it may be described as a tube running along the median line, and having an irregular series of openings into the entodermic cavity. The canal is lined by epithelium, which is thickened on the dorsal side to form the *Anlage* of the notochord. In transverse section the chorda appears according to the level of the section to constitute part of a furrow or a canal (compare also Heape, *loc. cit.*,[8] p. 441, Figs. 40, 41). Lieberkühn calls this canal mesoblastic, and Kölliker follows him; but this opinion seems to me based upon misconceptions. It is more reasonable to suppose that the canal is really the blastoporic canal, which is preserved for an unusually long period. We know that the blastopore first appears well forward, and as the primitive streak grows by concrescence of the ectental line (see Fœtus) the blastopore moves backward, its anterior portion fusing with the general entodermic cavity. There is no difficulty apparent in assuming that such fusion occurs quite late in mammals; this interpretation is confirmed by the fact that the canal becomes later a furrow throughout its entire length in front of the blastoporic canal proper, so that its cavity fuses with that of the entoderm proper.

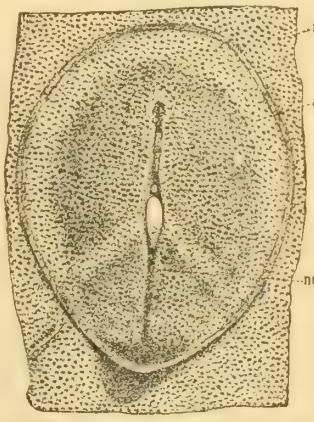

FIG. 2515.—Germinal Area of a Guinea-pig at Thirteen Days and Twenty Hours. (After Lieberkühn.) *ao.*, Area opaca; *ap.*, area pellucida; *nch.*, *Anlage* of the notochord as a canal with several irregular openings on the entodermic side. × 24 diameters.

After it is once formed as a band of cells the notochord passes through various changes of form, but ultimately becomes a cylindrical rod with tapering extremities. It attains considerable size in the embryos of most vertebrates, but in those of placental mammals is always small, particularly so in the mole (Heape[9]). It is probable that in mammals the notochord, when first separated from the entoderm, is a broad, flat band, as if compressed between the medullary canal and entoderm (*cf.* Kölliker, *loc. cit.*,[13] Figs. 194 to 197, and *loc. cit.*,[14] Fig. 94; also Heape,[9] Pl. XIII., Figs. 36 to 42). The band then draws together, diminishing the transverse and increasing the vertical diameter, until it has acquired a rounded form; finally its outline becomes circular in cross section. This series of changes begins near the anterior end of the chorda, and progresses both forward and backward.

The mesoderm early grows in between the entoderm and the notochord, which, however, for a considerable time remains close to the medullary tube (see vol. iii., Fig. 1251). Later the mesoderm penetrates between the notochord and medulla. The layer of mesodermic cells immediately around the notochord, which are of the well-known anastomosing type (vol. iii., Fig. 1245), forms a special sheath, which at first comprises only a single layer of cells, at least in batrachia (Götte,[5] p. 357, Fig. 187). This is the commencement of the so-called outer chorda sheath; it subsequently becomes much thicker. In the lower types it is an important axial structure (see vol. iii., Fig. 1254, *s'*); in most cases it is replaced by

cartilage, and in all the amniota the cartilage is replaced by the osseous vertebræ, the intervertebral ligaments, etc. The formation of the vertebral column involves the disappearance of the notochord as described below.

Histogenesis.—After the notochord has been formed as a rod of cells, its cells undergo a process of histological differentiation unique in vertebrates. The cells at first become greatly compressed in the line of length of the chorda, and hence appear quite thin in longitudinal

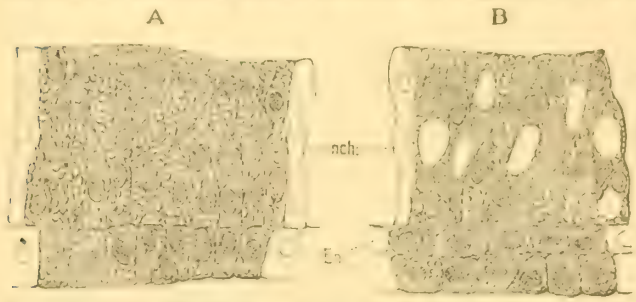

Fig. 2516.—Longitudinal Sections of the Notochord of Bombinator. (After Goette.) A, before the appearance of the vacuoles; B, after the appearance of the vacuoles. *nch.*, Notochord; *En.*, entoderm. (The cells, as is usual in amphibian embryos, are charged with yolk granules.)

sections (Fig. 2516, A, *nch.*)—hardly greater in diameter than their own nuclei. Thus, in the chick, by the third day some of the central cells become vacuolated, while the peripheral cells are still normal; at first, as in the frog, there seems to be only one large vacuole in each cell (Fig. 2516, B). Around the vacuole is a peripheral layer of granular protoplasm, in which the nucleus lies imbedded, while the vacuoles themselves are filled with a perfectly clear and transparent material, which is supposed to be fluid in its natural condition. During the fourth day (chick) all the cells become vacuolated, with the exception of a single layer of flattened cells at the periphery. In the anura, it is said, there is no distinct peripheral layer of protoplasmatic cells. The vacuoles go on enlarging until by the sixth day they have so much increased at the expense of the protoplasm that only a very thin layer of the latter is left at the circumference of the cell; at one part of which, where there is generally more protoplasm than elsewhere, the remains of a nucleus may generally be detected. Thus the notochord becomes transformed into a spongy reticulum, the meshes of which correspond to the vacuoles of the cells and the septa to the remains of their cell-walls (Foster and Balfour). As Goette has pointed out, the process is accompanied by an expansion of the cells, which is the main factor in the widening and lengthening of the notochord, which goes on, *pari passu*, with the growth of the surrounding tissue.

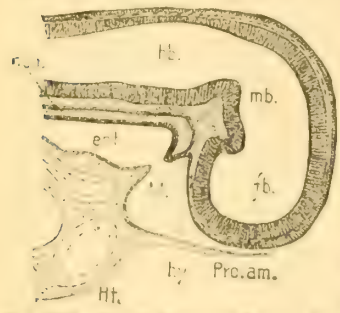

Fig. 2517.—Rabbit Embryo of 6 mm.; Median Longitudinal Section of the Head. (After Mihalkovics.) The connection between the mouth, *M.*, and pharynx, *ent.*, is just established. *nch.*, notochord; *hb.*, hind-brain; *mb.*, mid-brain; *fb.*, fore-brain; *pro.am.*, præamnios; *hy.*, hypophysis cerebri; *ht.*, heart.

The histogenetic process is stated to be essentially similar in mammals (W. Müller,[21] 337–338). There is the central layer of vacuolated cells and the peripheral layer of protoplasmatic cells. The latter are, however, ultimately converted into vacuolated cells. The cell-walls are perforate, having fine pores, that correspond probably to intercellular bridges of protoplasm. The inner chorda sheath appears early and is to be regarded as an anhistic basement membrane secreted by the notochordal cells.

Shape and Relations to other Parts.—As soon as the head-bend (first cerebral flexure) appears (Fig. 2517) the notochord becomes correspondingly bent, and its anterior extremity lies close to Rathke's pocket (Fig. 2517, *hy.*), the evagination of the oral epithelium, which is destined to form the pituitary body or *hypophysis cerebri*. The notochord never extends further forward than this, hence the skull and head may be divided into two parts, the præ-pituitary and the post-pituitary region. The latter region alone contains the notochord. Romiti[24] finds that in the chick the end of the notochord is united at the end of the fourth and during the fifth day of incubation with an irregular solid cord of cells, which grows out from the epithelium of the hypophysis. The cord soon disappears. Its significance is quite unknown. Romiti suggests that it may produce a strain resulting in the pulling out of the hypophyseal evagination. This notion seems to me untenable. The cranial portion of the notochord has not only the bend shown in Fig. 2517, but also follows the other curves of the head; it takes a sinuous course besides within the base of the cranium; finally, in the region corresponding to the middle third of the spheno-occipital cartilage, it makes a great dip ventralward. The sheath of the notochord in the cranial region is converted into the spheno-occipital cartilage; at the dip just mentioned, however, the notochord lies entirely below the cartilage, close against the wall of the pharynx (Froriep,[7] Romiti[24]). Writers before Froriep had represented the chorda as having disappeared at the bottom of the dip.

Disappearance.—The disappearance of the notochord in man commences with the second month of fœtal life. The first step is an alteration of the characteristic histological structure, accompanied by shrinking of the tissues, so that a clear space appears around it (see vol. iii., Fig. 1279). The inner chorda sheath is lost. The cell-walls disappear, the tissue becomes granular, and breaks up into

Fig. 2518.—Degenerating Notochord Tissue, from the Central Portion of the Intervertebral Disk of a Cow's Embryo. (After Lebaucq).

multinucleate, irregularly reticulate masses (Fig. 2518), which are gradually resorbed (Lebaucq[16]). In mammals the resorption progresses more rapidly in the cores of the vertebræ than in the intervertebral spaces, and again more rapidly at the ends than in the centre of each vertebra; hence the chorda persists a little longer in the centre of the vertebra, and considerably longer in the intervertebral spaces; in these last the final remnants of the chorda may be detected in man even after birth. The cavity between the vertebral cartilages is a new structure, and is not the space left by the notochord, as has been sometimes asserted. It appears, however, that the resorption of the chorda may leave a small space, which becomes included in the intervertebral cavity. A peculiar feature is the frequent persistence of calcified cartilage immediately around the notochord in ossifying vertebræ.[6]

Morphology.—The notochord was for a long time supposed to be exclusively characteristic of vertebrates. It is now known to exist in amphioxus, which is not a true vertebrate, and in the tunicata. Morphologists have long believed that it must have some homologue among the organs of invertebrates. The development of the notochord in the lower vertebrates indicates very plainly what must have been the general character of such an homologous invertebrate organ. In certain fishes and amphibia the notochord has been ascertained to arise as a furrow along the median dorsal line of the entoderm; the furrow deepens and then closes over to form a canal separate from the entodermic canal proper; but the noto-

chordal canal retains for a time its anterior and posterior connections with the entoderm. Ultimately the lumen is obliterated, the ends become detached, and so arises the solid isolated chorda. In the higher vertebrates the course of development is similar, although several of the primitive features in the formation of the chorda are obscured. Ehlers[3] has pointed out that in various invertebrates there is a similar canal, the "Nebendarm" of German writers, which is derived from the entoderm and connected anteriorly and posteriorly with the entodermal cavity. It is a very plausible suggestion, which homologizes the vertebrate notochord with the invertebrate "Nebendarm." Hubrecht has sought to homologize the notochord with the proboscis of Nemertean worms. There is not a single fact which seems to me to justify, even remotely, this attempt at guess-work phylogeny.

LITERATURE.—Very numerous embryological articles contain references to the chorda; below is given a list of the principal authorities. The best discussion is given by Balfour, in his "Comparative Embryology;"[2] the best observations on its origin in mammals by Heape.[8,9]. For its histology see W. Müller;[21] for its histogenesis see Götte;[5] for its anterior anatomical relations see Mihalkowics,[19] Froriep,[3a] Rabl-Rückhard,[22] and Romiti;[24] for its atrophy in mammals see Lebоucq;[16] for its evolution see Ehlers.[3]

Charles Sedgwick Minot.

[1] Balfour: A Monograph on the Development of Elasmobranch Fishes. London, 1878. (Reprinted Works, i., pp. 203–520.)

[2] Balfour: Comparative Embryology, vol. ii.

[3] Ehlers, E: Nebendarm und Chorda dorsalis, Nachr. Ges. Wiss., Göttingen, 1885, pp. 390–404.

[3a] Froriep: Kopftheil der Chorda dorsalis bei menschlichen Embryonen, Festschrift für Henle, 1882, pp. 26–40, Taf. iii.

[4] Gegenbauer, Carl: Ueber das Skeletgewebe der Cyclostomen (Histologie der Chorda, S. pp. 47–49), Jena Zeitschr. Nat. Wiss., v., 1869, pp. 43–53, Taf. i.

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NOVA SCOTIA. The accompanying charts, representing the climate of the city of Halifax, Nova Scotia, may be useful to readers of the HANDBOOK, as conveying to them a fairly accurate understanding of the climatic conditions which prevail in that province during the summer and autumn months. For Canadian readers such information will possess a special interest.

The data of the tables were obtained through the kindness of the Hon. H. Beaumont Small, of Ottawa. The caution respecting the due interpretation of data in the Montreal chart (Table A, pp. 17 and 18), and in particular respecting columns G, H, and L of that chart, applies equally to this corresponding chart for Halifax.

The data of both tables make it abundantly manifest that it is only during the summer and the first two autumn months that Nova Scotia can be regarded in the

TABLE A.

Climate of Halifax.—Latitude 44° 39′, *Longitude* 63° 36′.—*Period of Observations, January*, 1883, *to December*, 1883.—*Elevation of Place of Observation above the Sea-level*, 122 *feet.—Name of Observer*, A. ALLISON.

	A			AA	B		C	D	E		F		G	H
	(1883.) Mean temperature of months at the hours of			Mean temperature in 1883, deduced from Column A.	Mean temperature for period of observation (1867–83).		Average maximum temperature in 1883.	Average minimum temperature in 1883.	Absolute maximum temperature in 1883.		Absolute minimum temperature in 1883.		Greatest number of days in any single month on which temperature was 32° and below (1883).	Greatest number of days in any single month on which temperature was 32° and below (1883).
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Lowest. Degrees.	Highest. Degrees.		
January	12.98	20.66	15.97	16.53	29.50	16.79	26.28	7.64	42.2	2.8	−8.4	30.2	31	0
February	15.70	24.47	17.52	19.23	26.88	17.99	38.94	10.95	43.0	11.0	0.0	22.8	28	0
March	23.99	30.30	24.30	26.19	32.99	22.91	33.54	17.58	46.2	15.1	−7.0	34.0	28	0
April	34.56	43.80	33.59	37.31	40.81	33.30	45.92	29.18	65.0	35.4	18.2	38.8	20	1
May	46.86	54.30	44.87	48.67	50.68	44.26	57.35	39.86	70.3	43.0	29.8	48.8	3	10
June	57.38	65.80	54.02	59.06	60.53	52.96	68.82	50.15	80.4	57.1	43.2	57.1	0	27
July	60.12	68.33	56.72	61.72	66.51	60.77	70.85	53.66	81.7	61.7	46.7	61.0	0	30
August	61.33	71.32	57.94	63.53	66.62	59.62	73.26	54.18	81.2	59.8	45.6	60.0	0	31
September	53.93	64.89	52.71	57.17	59.77	54.12	65.66	47.03	76.8	57.3	40.5	55.5	0	25
October	43.56	50.58	43.28	45.80	51.31	44.30	54.23	38.28	73.4	44.0	29.0	57.8	7	5
November	33.94	41.82	36.73	38.16	39.55	32.00	45.91	31.06	58.2	29.0	8.6	46.2	12	0
December	24.51	28.84	25.52	26.29	32.05	18.81	34.51	18.42	46.8	4.0	−11.2	39.6	28	0
Second quarter	.....	.....	.....	.....	49.53	45.41	.....	.....	.....	.....	.....	.....	....	....
Third quarter	.....	.....	.....	.....	63.30	60.17	.....	.....	.....	.....	.....	.....	....	....
Fourth quarter	.....	.....	.....	.....	39.30	35.46	.....	.....	.....	.....	.....	.....	....	....
First quarter	.....	.....	.....	.....	27.25	19.15	.....	.....	.....	.....	.....	.....	....	....
Year	.....	.....	.....	41.64	44.47	40.23	.....	.....	.....	.....	.....	.....	....	....

	J	K	L	M	N	O
	Range of temperature between 9 A.M. and 3 P.M.	Mean humidity at 9 A.M. (Saturation = 100)	Number of days on which rain fell	Total movement of wind in miles	Direction of prevailing wind	Average velocity of wind in miles per hour
January	50.6	86	13	2 49	W.N.W.	4 88
February	43 0	83	11	2 43	W.N.W.	7.10
March	45 2	82	11	2 64	W.	9 75
April	46 8	79	16	2 63	S.E.	6 71
May	49 5	79	12	2 67	S.	6 36
June	33 2	82	16	3 32	S.E. & W.	4 51
July	33 2	84	19	3 31	S.E.	4 88
August	33 6	86	16	3 31	S.W.	4.88
September	43 3	83	21	3 84	W.S.W.	5 78
October	44 4	84	15	3 83	W.	6 67
November	49 6	85	8	2 63	S.W.	7 67
December	58.0	87	14	4.01	N.W.	8.51
Second quarter	62.2	81	41	14 86	.....	5 86
Third quarter	41.2	85	56	12 71	.....	5 18
Fourth quarter	84 6	85	37	12 45	.....	7 72
First quarter	54 6	84	35	8 41	.....	8 35
Year	92.9	84	172	48 52	.....	6 75

light of a place of resort. At that season, however, the good facilities for hunting and fishing are an attraction to some persons who have become debilitated by the summer heat of a large city, provided they do not object to the high atmospheric humidity and to the fogs which they may encounter, and provided they take with them a supply of clothing suited to a damp and a decidedly cool summer and autumn climate. The western portion of Nova Scotia is the most picturesque, and is historically the most interesting.

The low temperature, dampness, and raininess, and the frequency of fogs, even in the summer season, mark the climate as typically a northern one. The mean temperature during the months of June, July, August, and September is about the same as that found during corresponding months in the British Isles. During the other months of the year, and especially in the winter season, it is very much lower.

Certain sufferers from hay-fever enjoy perfect immunity from that disease at Halifax, and probably the same experience may be had at many other points in Nova Scotia. With this exception, however, I certainly

TABLE B.

	Average mean temperature for a series of years.	Mean temperature.		Absolute maximum temperature.		Absolute minimum temperature.		Rainfall in inches.		Depth of snow in inches.		Number of days on which rain fell.		Number of days on which snow fell.		Percentage of cloud.		Monthly range of temperature		Mean daily range of temperature		Greatest daily range of temperature		Mean velocity of wind.	Maximum velocity of wind	Number of fogs.
		1881	1882	1881	1882	1881	1882	1881	1882	1881	1882	1881	1882	1881	1882	1881	1882	1881	1882	1882	1882	1882	1882	1882	1882
January	22 21	20 6	21 6	42 5	45 6	0 0	−8.0	3 54	3 16	8 7	36 8	8	9	9	13	72	58	42 7	35 6	16 66	32 1	7 54	32 0	32	2
February	23 05	25 0	22 6	48 2	42 9	0 8	−8.9	2 91	1.67	34 9	12 8	8	5	11	15	64	62	47 1	45 8	17 71	38 3	10 49	29 0	1	1
March	28 68	32 9	28.1	11 9	2 44	3 20	5	6.0	5 93	5 46	6 4	15 9	7	9	5	13	63	64	28 7	33 5	14 58	24 0	8 46	33 0	5
April	37 50	36 6	38 5	58 8	55 8	15 7	13.2	3.21	3.68	2.6	11 2	11	8	9	11	54	65	48 1	42 6	14 84	27 6	8 66	30 0	3	3
May	45 72	45 3	44 5	77 0	69 4	30.2	28.1	2.46	4.66	..	..	17	14	..	..	65	59	46 8	41 3	17 58	29 9	8 22	35 0	10	10
June	57 26	58 0	57 0	93 5	78 6	37.9	39.0	5.50	5.51	..	..	18	17	..	..	68	58	55 6	39 6	19 78	32 9	9 82	29 0	15	15
July	63 40	61 5	64 1	86 5	86 7	48.0	42 6	3 18	5.18	..	..	17	15	..	..	60	60	38 5	39 4	19 16	38 7	5 40	16.0	8
August	63 77	64 1	64 1	88 8	90 2	51 4	44 6	3 64	2 93	..	..	13	11	..	..	72	48	38 4	45 6	20 96	35 7	5.54	17.0	6
September	57 56	59 7	58.4	88 2	80 5	39 0	40 1	3.11	5 92	..	..	12	17	..	..	57	66	44.2	39.9	14.43	27.3	6 19	25 0	7
October	47 99	46 5	49.7	77 8	76 8	25 0	30.0	4.21	7 52	8	..	18	13	2	..	59	50	50 8	40 8	11 62	32 3	6 56	26 0	3
November	37.60	36.7	36 9	59 4	63 8	19 0	25.8	3.12	0.81	13.0	5.6	13	8	8	7	58	64	49 4	38 0	19 86	28 1	8 13	35 0	1
December	25.14	31 1	27.2	51 1	50 0	3 8	11.0	6.57	1.31	4 3	21.4	15	7	2	15	67	62	47.5	39 0	12.14	31.0	8 14	48 0	.
Year	42.74	42.94	42 50	89.8	90.2	0.0	−8.0	45 83	51.72*	58.9	133 7	157	133	46	74	61	60	89.8	98.2	16.02	34.3	7 38	31 0	59
								48 81	62.18*			203†	207†												

* Combined rain and melted snow.

† Number of days on which either rain or snow fell: that is, of days which were not "fair" days, according to the interpretation of this term by the Canadian Meteorological Service.

am of the opinion that resort to Nova Scotia as a sanatorium for the genuine invalid can by no means be recommended. *Huntington Richards.*

NURSES, TRAINING SCHOOLS FOR.—Training Schools for Nurses are institutions established in connection with hospitals and dispensaries to furnish practical instruction in nursing the sick. At present the organized schools are adapted only for female nurses, but the desirability of training male orderlies with the same thoroughness is receiving attention. The schools are an outgrowth of the recent progress in medical and surgical scientific methods, which demand greater system and skill in nursing than have heretofore prevailed. The schools possess none of the essential elements of religious orders and sisterhoods. Their first object is to benefit hospital patients, but their graduates nurse among private families and the poor, or become head nurses in institutions. This new field of work often attracts women of more refinement and better social position than those who used to be employed in hospitals, and after graduation they are sure of almost constant employment at high wages.

Foreign Nursing Systems.—Organized nursing schools are of very recent date, and their establishment arose from the experience of army hospitals in European wars, especially the Crimean War. The nurses of religious sisterhoods, midwives, and monthly nurses were originally the women who followed nursing as an occupation. In France the nursing is mainly in the hands of Roman Catholic sisterhoods, and in the hospitals of Paris alone are over six hundred sisters who superintend the hired attendants. In Russia the Sisters of Mercy have done the nursing since the Crimea, and in Italy a similar arrangement obtains. But in January, 1883, the "St. Paul's Home for Trained English-speaking Nurses" was started in Rome by a few graduates of American and English training schools. This institution has been very successful. Its object is, however, merely to afford a home to nurses who have been trained elsewhere. In Germany, among a great variety of Protestant and Roman Catholic nursing systems, many have become famous. Pastor Theodor Fliedner founded the "Institute of Deaconesses" at Kaiserwerth in 1836, where, in after years, Miss Nightingale completed the early training which made her such a successful advocate of thorough instruction in nursing. There are upward of three thousand deaconesses at present connected with this institute, and with others in Germany modelled after it. There are many Sisters of Charity who serve as nurses, and one of the best secular schools similar to the training schools is at the "Kaiserin Augusta Hospital" in Berlin.

The "International Hospital and Field Service Society of Surgeons and Nurses" became famous on foreign battle-fields, and after the experiences of the two last German wars the "Albert Verein" was organized in Dresden and Leipzig. The nurses of this society are thoroughly trained by practical courses and lectures. Rewards and favors are granted for merit, and if, after

three years of active service, their health should become impaired, they are pensioned. They are sent out from the school to nurse private cases.

In Vienna the nursing is done by sisters, and also by women who work without special organization. In England female nurses in hospitals are mentioned as early as 1760, and in 1791 they were indorsed by the Governors of the London Hospital. In 1801 there were women nurses in the Woolwich Artillery Hospital. For the past thirty years special attention has been directed in England to nursing systems. At Guy's Hospital nurses were trained by Mrs. Elizabeth Fry for many years before a school was formally opened in November, 1879. The Protestant orders of St. John and of All Saints for many years performed satisfactorily the nursing for King's College Hospital, Charing Cross Hospital, and the University College Hospital. The Order of St. John sent nurses with Miss Nightingale to the Crimea. In June, 1860, a training school was founded at St. Thomas' Hospital, London, through the generosity of Miss Nightingale. This school, after being in successful operation for several years, was made the subject of special study by the New York State Charities Aid Association, and taken as a model for the Bellevue Hospital School, as well as for most of the other American schools. In 1874 a school was opened at Westminster Hospital, London, and ten years later a special building was erected with accommodation for fifty nurses. It is desired to establish district nursing among the poor in connection with this school. In 1861 a training school was founded in Liverpool for district nursing, and a great reform in the quality of nursing was instituted at the Liverpool Workhouse. In 1866 there were two schools in Dublin, and there is now an excellent school at the Glasgow Royal Infirmary. In 1867 a school was founded at the Sydney Infirmary, New South Wales. There are also new schools in Russia, Sweden, and Holland.

American Nursing Systems.—Toward the end of the eighteenth century Dr. Valentine Seaman gave a course of twenty-six lectures to the nurses of the New York Hospital upon important topics in relation to nursing and hygiene. These lectures were published in 1800, and they are the first recorded effort for the improved training of nurses in the United States. In Philadelphia in 1838 the Society of Friends formed a nurse society by which they raised the standard of nursing and relieved the Roman Catholic sisterhoods from doing the work alone. The Philadelphia Lying-in Charity has instructed nurses in special branches for forty-two years. St. Luke's Hospital in New York has been supplied since 1853 (until recently) with nurses of the Protestant Episcopal Order of the Holy Communion. Several Lutheran charitable societies have trained nurses in various parts of the country, and some two thousand of these women served during the War of the Rebellion. During this war women-nurses were also sent to the field and hospitals under the auspices of the Sanitary Commission and of the American Society of the Red Cross. The latter society, aided by the enthusiasm of Miss Clara Barton, has done a great deal in recent years to nurse the sufferers from yellow fever and from floods in the South and elsewhere. At Syracuse, N. Y., a Protestant Episcopal sisterhood has nursed for the Hospital of the Good Shepherd for ten years, and the deaconesses are sent out to nurse in private families, in other institutions, and among the poor. Many excellent orders of like nature have long existed throughout the country for the purpose of training and supporting nurses.

In 1873 three training schools for nurses were almost simultaneously established in New York, New Haven, and Boston, and from this year dates the impetus to the improved nursing system which has led, in fourteen years, to the establishment of over thirty-five schools in various cities of the United States, with an outlay of many thousand dollars. There have been thus far nearly two thousand nurses graduated.

The Training Schools are governed either by the trustees of the hospital or infirmary to which they are attached, or by a special committee of their number, or they are under the government of a specially incorporated society which merely co-operates with the hospital authorities. Experience has demonstrated that concentrated management under existing hospital government is usually the most successful system for operating the schools. There is a woman superintendent or matron, with an assistant if required, for each school. The schools are supported out of the general hospital funds, or by endowments, bequests, or annual subscriptions. About twelve of the schools have separate buildings for nurses' dormitories, dining and lecture-rooms, etc. The advantages of buildings separate from the hospital wards, in promoting better health among the nurses and more complete relaxation when relieved from duty, are obvious. The course of instruction, similar in all the schools, extends over one or two years. In almost all cases it covers two years, and the nurses agree not to leave before the completion of the service. The usual limits of age for pupils are between twenty-five and thirty-five years. The candidates for admission must conform to a satisfactory standard of height, weight, and good health ; and appropriate qualifications in character, common-school education, neatness, cheerfulness, dexterity, etc, are required. Applicants are admitted for the first month on probation. After this they are allowed to wear a plain uniform of a gingham dress of seersucker pattern and large apron, with a muslin cap, and they are gradually promoted until, during the last six months of the course, they are put in charge of a ward as "head nurses." After the first month an allowance of from five to sixteen dollars is granted each pupil in accordance with her length of service. This is intended merely to meet the expenses of the uniform, etc. Board, lodging, and washing are furnished free from the commencement. The health of the nurses is not usually impaired. Those who come from active country life are apt to suffer most from the confinement. If taken ill they receive treatment gratis. During the entire course the principal of the school holds recitations and occasional examinations, and the nurses are finally examined and graduated by a committee of the medical staff of the hospital. Their services may be optionally required by the hospital for six months longer. After this time they leave permanently, and nurse in private families, where they command wages of $20 a week. In addition to instruction from the lady principal, the head nurses are required to instruct those under them in the details of the care of the wards, and one or more lectures a week are given by the medical staff of the hospital upon diet, ventilation, disinfectants, medical and surgical emergencies, and the observation and recording of such phenomena as may occur between the physicians' visits, as chills, convulsions, cough, coma, etc. Elementary lectures are also given upon anatomy, physiology, fractures, the nursing of fever, and other special topics. (For the ward instruction see the following article, on Nursing the Sick). Instruction in cooking for invalids and in massage is also afforded at the best schools. In hospitals not having a maternity service, arrangements are made to supply the nurses with cases of obstetric nursing elsewhere for a few months. Each nurse during her course is allowed to serve in the medical, surgical, gynæcological, and children's wards, in the operation theatre, reception wards, and dispensary. After three months' experience she may be put upon night duty, or have continuous charge of some special case. The nurses are on duty from 7 A.M. to 7 P.M., with appropriate intervals for meals, and an hour in the afternoon for rest or recreation. The evenings are free, excepting those reserved for recitations, and two afternoons a week are allowed for rest. A vacation of two weeks is granted in each year.

The Principal Training Schools at present existing in the United States are as follows, with the dates of their organization :

The Nurse Training School of the Woman's Hospital, Philadelphia, 1863.

The Training School for Nurses at the New England Hospital for Women and Children, Boston, 1872.

The Bellevue Hospital Training School, New York, 1873.

The Connecticut Training School for Nurses, New Haven, Conn., 1873.

The Boston Training School for Nurses at the Massachusetts General Hospital, 1873.

The Training School for Nurses at Charity Hospital, New York, 1875.

The New York Hospital Training School for Nurses, New York, 1877.

The Hartford Hospital Training School for Nurses, Hartford, Conn., 1877.

The City Hospital Training School for Nurses, Boston, 1877.

The Washington Training School for Nurses, 1877.

The Buffalo General Hospital Training School for Nurses, Buffalo, N. Y., 1877.

Training School for Nurses at the Brooklyn Homœopathic Hospital, Brooklyn, N. Y., 1878.

Training School for Nurses of the Rochester City Hospital, 1880.

The Brooklyn Training School for Nurses, Brooklyn, N. Y., 1880.

The Illinois Training School for Nurses, Chicago, Ill., 1881.

The Mount Sinai Training School for Nurses, New York, 1881.

The Training School for Nurses at the Long Island College Hospital, Brooklyn, N. Y., 1882–83.

The Mary Fletcher Hospital Training School for Nurses, Burlington, Vt., 1882.

Training School for Nurses at the Orange Memorial Hospital, Orange, N. J., 1882.

The Training School for Nurses at the Charity Hospital, New Orleans, 1882.

The Training School for Nurses at the Northwestern Hospital for Women and Children, Minneapolis, Minn., 1882.

The Rhode Island Hospital Training School for Nurses, Providence, R. I., 1882.

The Cincinnati Training School for Nurses, Cincinnati, O., 1883.

Farrand Training School for Nurses, Harper Hospital, Detroit, Mich., 1883.

The Charleston Training School for Nurses, Charleston, S. C., 1883.

Training School for Nurses at the General Hospital, Paterson, N. J., 1883.

Training School for Nurses of the City Hospital, Indianapolis, Ind., 1883.

Cleveland Training School for Nurses, Cleveland, O., 1883.

Training School for Nurses of the City Hospital, Worcester, Mass., 1883.

Training School for Nurses, Johns Hopkins Hospital, Baltimore, Md. (dormitory completed 1887, not yet opened).

Several schools of midwifery have been in successful operation for many years. Prominent among these are the Philadelphia Lying-in Charity and Nurse School, 1832; the Missouri School of Midwifery, 1875; the New York State School for Training Nurses at the Brooklyn Maternity, Brooklyn, N. Y., 1872.

There are several central public "nurse directories," where any nurse in good standing ("trained" or not) may leave her address, references, and testimonials. From these central directories families may obtain nurses promptly on application.

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William Gilman Thompson.

NURSING THE SICK. Although nursing the sick has always been in practice among civilized people, it is within comparatively very recent years that any systematic instruction has been given in this art, or that any special books have been written upon the subject. The increasing appliances and inventions for adding to the comfort of the sick-room, the enormous growth of hospitals, the perfection of ambulance services upon fields of battle, and the advances in the science of medicine and surgery have all contributed to make it both necessary and profitable for many persons to devote their lives to nursing and to acquiring the skill through years of practice which is to-day demanded in the treatment of every serious injury or illness. (See preceding article, on Training Schools for Nurses.)

It is impossible here to more than enumerate the many important duties with which a nurse should be familiar, the details of which are fully cited in many excellent and practical treatises upon nursing.

The physical strain of the work is so great that it is essential for a nurse to be of the best possible health and physique, and the qualities most necessary in addition are cheerfulness, gentleness, obedience, sobriety, and cleanliness. It is advisable in order for a nurse to act intelligently, that she understand the elementary principles of hygiene, physiology, and antisepsis, as well as the rudiments of anatomy and the nature of the commonest poisons and the emergency treatment of poisoning.

In the training-schools nurses are taught at the bedside such practical matters as the application of cups, leeches, blisters, poultices, stupes, baths of all kinds, the use of enemata, nutrient and otherwise; the use of douches, catheters, appliances for uterine disorders, trusses, etc.; the control of sudden hæmorrhage; changing the bed-clothes without raising the patient; the preparation of all kinds of bandages and splints, the simplest forms of bandaging and of minor surgical dressings, the chemical examination of the urine, recording the rate of the pulse and respiration, the use of the clinical thermometer, avoidance and care of bed-sores, cleansing utensils; the proper manner of giving the medicines prescribed, including the method of hypodermatic injection, inhalations, etc.; observation of the appetite, thirst, sleep, and of the effects of certain diets and medicines, the management of convalescents, and the methods of keeping written records of cases.

In many schools special tuition is provided in massage, and also in cooking delicacies and preparing beverages, etc., for the sick.

Nurses are further instructed in the observation and recording of such symptoms as may arise suddenly between the physician's visits; for example, the first appearance of eruptions, chills, coma, delirium, pain, convulsions, sweating, expectoration, etc.

Duties of Hospital Nurses.—The details of ward work vary in the different hospitals, but in those institutions where there are training-schools the usual routine is as follows: The head nurse of a ward has charge of fifteen to thirty beds, and she is required to enforce proper decorum and to see that the patients under her care accept the treatment prescribed. She is assisted by a senior and a junior nurse or "probationer," and in male wards by an orderly. Her first morning duty (commencing usually at seven o'clock) is to receive the report of the night-nurse and to learn of any changes in the physician's orders which have been made. The bed-clothing is then freshly arranged for the day, and she devotes her personal attention to the most serious cases and to instructing her aids. She then sees that the standing orders for the morning are fulfilled, and prepares a list of necessary ward supplies which list is to be sent to the apothecary after receiving the physician's approval. Meanwhile the senior assistant records the patients' pulse, respiration, and temperature, while the junior nurse serves their breakfasts. The ward being in order for the day, the nurses all accompany the staff upon their rounds, and stand in readiness to serve them and assist at operations or the dressing of wounds. There are then new orders to be fulfilled, patients arrive or are discharged, and their clothing and ward linen must be cared for. The heavier work of scrubbing the floors, scouring the bedsteads, etc., is left to special ward maids. The head nurse must be prepared at all times to give the physician a concise account of the patients under her charge since his previous visit, and she is responsible for the execution of all

his orders by herself or her assistants. When a patient dies it is the further duty of the nurse to see that the body is properly cared for.

Duties of Private Nurses.—In nursing patients in private families there is usually much less routine than in hospital work, and nurses often have to exercise more tact and judgment, and to assume more responsibility. The intervals between the physician's visits are longer, and patients cannot be subjected to the general discipline of a hospital ward. The nurse must learn how to regulate the ventilation and temperature and light of the sick-room. This work in a hospital is commonly left to the engineer or superintendent. She must pay attention to the general order and neatness of the room, keep medicines out of sight, remove dishes and utensils promptly after use, and remove disagreeable odors. She must study to aid the patient's toilet, so as to cause as little fatigue as possible in washing the face, cleansing the teeth and tongue, combing the hair, etc. She must know how to aid sleep, by regulating the light, securing quiet, seeing that the patient is in a comfortable position, smoothing pillows and sheets, etc. She must take pains to prevent cold feet, learn the proper management of bed-pans, and learn the importance of the recumbent position in certain diseases, and the best methods of applying restraint in delirium and mania. She must know the uses and methods of preservation of ice, and how to peptonize milk and beef-juice, etc.

There are very many other details which can only be learned in actual practice, and there is a wide field, in private nursing especially, for the exercise of ingenuity and tact, and for the adaptation of the best means at hand for securing the comfort and well-being of the patient without unnecessary trouble or expense.

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William Gilman Thompson.

NUTGALLS (*Galla*, U. S. Ph., Br. Ph.; *Gallæ*, Ph. G.; *Galle de Chêne d'Alep, ou Noix de Galle d'Alep*, Codex Med.; Aleppo, Turkey, or Levant Galls). These are pathological developments of the leaf-buds of *Quercus lusitanica infectoria* A. D. C., the Nutgall oak, occasioned by the sting of a small, wasp-like fly, *Cynips Gallæ tinctoriæ* Olivier; Order, *Hymenopterœ*.

Q. lusitanica is a widely disseminated and variable species, growing over the greater part of Southern Europe, in the Levant, and in Western Asia. It differs from *Q. robur*, the English Oak, in its generally smaller size, less deeply lobed leaves, and rather longer fruit. The variety upon which these Galls grow is one of the smallest, being only a shrub one or two metres in height, with irregular, spreading branches, downy twigs, and oval, deeply and bluntly serrate, but not lobed, leaves. The acorn is almost cylindrical, and rests in a deep, rather narrow, cup. It is a native of Asia Minor, Cyprus, Turkey, Greece, etc. The fly whose puncture causes the galls is a small, wasp-like insect, about six millimetres long (¼ inch), with a brown body, short antennæ, and four transparent wings, of which the anterior are much the larger. Underneath the abdomen the female carries an ovipositor.

The production of the nutgall is as follows: The female *Cynips* punctures with her ovipositor certain of the unexpanded buds, and leaves a single egg in each, after which the bud so attacked, instead of developing into a branch, swells to a globular, tuberculated, solid, and finally very hard excrescence, one or two centimetres in diameter, in the midst of which the egg is imbedded. This then hatches a soft-bodied larva, which eats out, as it grows, a spherical chamber in the centre of the gall, passes through its pupa stage in this home, and finally, as a fully developed fly or wasp, gnaws its way out through a cylindrical tunnel, one or two millimetres in diameter. Thus it is seen that this product is in no sense the fruit of the plant, but only a diseased condition of it.

On account of their geographical origin, near the highway of ancient commerce, nutgalls could hardly fail to be known at a very early period, and accordingly they are frequently mentioned by writers of antiquity, both as medicine and for their more important uses in tanning and dyeing. They have been in long-continued use also in India and China.

Description.—Aleppo Galls are very hard, nut-like bodies, from one to two centimetres in diameter, of a generally spherical shape, rather pointed at the base, and

Fig. 2519.—The Nutgall Oak, showing Leaves, Acorns, and One Nutgall. (Baillon.)

irregularly tuberculated over the surface, particularly the upper half, with points probably corresponding to leaves or leaf-scales in the bud. The surface is smooth and faintly shiny; its color, if it is gathered while still green and before the escape of the insect, is a dark-bluish olive; if gathered after this event, it is lighter and yellowish, or grayish-brown. In this case, also, the aperture made by the fly is to be seen somewhere upon its surface. The texture of galls is very hard and brittle, more like that of a nutshell than of wood, splitting under the hammer, and requiring a saw to cut them. Color within greenish or brownish-yellow. In the centre the smooth globular cavity is surrounded by a layer of thick-walled cells, making a pretty distinct shell. The remains of the insect may be found in this cavity, unless it has already escaped. If the gall is collected very young, it will be immature and small, or even not hatched, and the cavity filled with soft, amylaceous parenchyma. Galls are very dense and heavy. The younger, not perforated ones, are

darker, heavier and richer than the older, and they are generally sold separately.

Composition.—This drug is remarkable for the enormous percentage of *tannic acid* (gallotannic acid, $C_{14}H_{10}O_9$) that it contains, amounting in good lots to more than half, and in the best grades to nearly three-fourths by weight. This remarkable type of all vegetable astringents was discovered in 1793 by Deyeux, and two years later by Seguin in nutgalls. It is also found in the galls of several other species of oaks, in the hollow galls so called, of the leaves and petioles of the Japanese *Rhus semialata*, and in a few fruits and certain vegetable products; but, although very closely related, tannins are among the commonest of vegetable products; this particular kind is not otherwise so widely distributed. The tannin of oak-bark and acorns, for instance, is not exactly like it. Gallotannic acid is a colorless, or, as usually seen, light brown, very light and flocculent, amorphous, glistening, slightly hygroscopic substance, with little or no odor, but having a strongly astringent and puckering taste; not at all bitter. Soluble in six parts of water and in less than one of spirit, insoluble in anhydrous ether, but soluble in ether containing a little water. Reaction strongly acid; basic power very great, replacing most acids in combination. Exposed to the atmosphere when damp, or in solution, tannic acid slowly undergoes a sort of glucoside decomposition, of which *gallic* acid is the most important result. A number of the ordinary vegetable ferments and dilute mineral acids promote this change. Nutgalls also contain a very small percentage of *gallic acid*, probably produced by a natural decomposition of some of the tannin. *Sugar*, a little *starch*, *resin*, etc., are among the widely distributed vegetable substances also found in them.

The separation of tannic acid from Galls is easily accomplished, but its absolute purification is exceedingly difficult. That of the market is usually obtained by mixing the crushed and very slightly dampened Galls with enough washed ether (*i.e.*, ether saturated with water), to make a paste, pressing out the liquid, repeating the process once or twice, and finally evaporating; or a mixture of ether and alcohol is used; or the tannin may be washed out of its ethereal solution, and after separating the liquids the watery solution evaporated to dryness. To produce gallic acid, the common way is to macerate the powdered Galls in enough distilled water to form a paste, for a month or more, until the conversion of the tannic acid is complete, replacing the water from time to time as it evaporates; then the mass is pressed dry, the water expressed being thrown away, and the residue boiled in an abundance of fresh water, which is filtered, while hot, through animal charcoal, and set aside to crystallize. The gallic acid, which is fairly insoluble in cold water, dissolves easily in the boiling water, and is separated again upon cooling.

Gallic acid is a "colorless solid, crystallizing from water in long, silky needles, or triclinic prisms, permanent in the air, odorless, having an astringent and slightly acidulous taste and an acrid reaction. It is soluble in one hundred parts of water and in 4.5 parts of alcohol, at 15° C. (59° F.); in three parts of boiling water, and in one part of boiling alcohol," less soluble in ether, chloroform, etc. Both gallic and tannic acids form a deep blue-black precipitate with persalts of iron, which is the basis of many inks and dyes. Tannic acid, in addition, precipitates solutions of the alkaloids and their salts (forming tannates), albumin, gums, and gelatin, which latter property gives it its most important field of usefulness, viz., in tanning leathers. At a high temperature tannic acid is transformed into pyrogallic acid, which finds very extensive use in developing photographic negatives and for other purposes in the arts.

Action and Use.—As Nutgalls are essentially tannic acid, the latter may be taken to represent them. This substance, so far as it can penetrate the skin, coagulates the albumin and gelatin that it reaches, and "tans" it; this, however, takes place to a very slight extent only: on the unbroken epidermis, for instance, it has almost no action, being not absorbed; upon a raw surface, however and upon mucous membranes it produces contraction of the tissues and a hard dense surface, with diminished secretion and coagulation of albuminous liquids like mucus or blood-plasma, an action which is common to nearly all the vegetable astringents. If too concentrated or long applied irritation and inflammation may follow, or in case of the intestinal surface, diarrhœa and vomiting, instead of the constipation produced by smaller doses. The absorption of tannic acid, *per se*, has been long questioned, and probably does not take place to any great extent, but there is reason to believe that in some degree it may occur. In the stomach and intestines it is chiefly converted into gallic acid, which is readily absorbed and carried in the circulation; this, while it has the general properties of tannin, is less irritating and more useful where remote effects are desired. Flabby granulating surfaces, subacute inflammations of the mucous membranes of the mouth, pharynx, or nares; hæmorrhoids, etc., are often benefited by topical applications of tannic acid; thin-skinned nipples in nursing women are hardened and toughened by it; in leucorrhœa and gonorrhœa it is often beneficial; in chronic diarrhœa and gastric and intestinal hæmorrhage occasionally so. It is a chemical antidote to tartar-emetic poisoning, and to that of alkaloids, if applied in season.

Gallic acid is a more appropriate astringent when indirect action is hoped for, as in hæmoptysis, hæmaturia, bleeding from cancer of the uterus, etc. It is also used in excessive bronchorrhœa, and, like tannic acid, in relaxation of the bowels of a chronic or non-inflammatory nature. It is scarcely as useful, however, as the best mineral astringents—lead, for instance. Dose of either acid one gramme (ten or fifteen grains or more).

Administration.—Nutgalls are seldom given in substance; but an infusion may be used locally. The officinal preparations are: a Tincture (*Tinctura Gallæ*, U. S. Ph.), strength $\frac{1}{5}$, in alcohol and glycerine; an Ointment (*Unguentum Gallæ*, U. S. Ph.), strength $\frac{1}{10}$, wholly superfluous, and the two acids above described. From each of these an ointment (*Unguentum Acidi Tannici*, *Unguentum Acidi Gallici*, U. S. Ph.), strength ten per cent. in each case, is made, with Benzoinated Lard. Besides these are Troches of Tannic Acid (*Trochisci Acidi Tannici*, U. S. Ph.), strength about ten per cent., useful in chronic pharyngitis, etc.; and Styptic Collodion (*Collodium Stypticum*, U. S. Ph.), strength $\frac{1}{5}$, a not very useful preparation.

Allied Drugs.—Other species of *Cynips* produce galls upon various oaks and other trees, a few of which have been put to use, but none of them compare in importance with the subject of this article. Most of them contain abundance of tannin; others are agreeably sour from the presence of some of the fruit acids. Besides these, numerous other insects occasion analogous phenomena in many other plants; the "juniper apples," on our Virginia juniper, "swamp apples" upon the swamp azalea, the swollen and acid leaves found occasionally on huckle- or blue-berry bushes, the inflated stems of certain compositæ, and many others are common instances. A most remarkable development is that known as Chinese or Japanese galls, in the form of irregularly-lobed and pointed, often fantastic, thin-walled vesicles, from three to eight centimetres in length, of a greenish, velvety surface, and brittle texture. They contain within the debris of several generations of plant-lice (*Aphis chinensis*), whose presence occasioned them. They grow on the Asiatic sumach (*Rhus semialata*). Although constantly in Chinese commerce, they rather rarely appear here. Their composition is similar to that of Aleppo Nutgalls. *Myrobalans* are the fruits of various species of *Terminalia*; they are articles of Asiatic commerce, but seldom found here. Tannic acid is their chief constituent. Besides these, the barks of various *Sumachs*, *Acacias*, and *Cinchona* abound in it, and are in extensive use for tanning. Among drugs containing large amounts of tannic matters may be mentioned Catechu, Kino, Krameria, Blackberry, Spiræa, Tormentilla, Bearberry, Avens, Areca nuts, Geranium, and many more, besides which it is an incidental ingredient of a large number of others,

valued for different qualities, as Kooso, Pomegranate, Red Cinchona, etc.; indeed, it is present in some degree in the great majority of vegetable substances. The cincho- or kino-tannic group, giving greenish or olive salts with the salts of iron, is more general in its distribution than the gallo-tannic or querci-tannic. The vegetable astringents differ somewhat in their action from the mineral ones, of which the most important are ferric alum, and other alums, copper sulphate, zinc sulphate, silver nitrate, ferric chloride, and subsulphate, and in a milder degree lime and bismuth.

Allied Plants.—*Q. lusitanica* exists in a number of varieties, some of which, as well as perhaps some varieties of *Q. Robur*, contribute a small share of the Aleppo Galls. *Q. Robur*, the British oak, is a widely distributed European tree, highly valued for its hard and durable timber. Its bark, as well as that of many other oaks, is extensively used in tanning, and occasionally in medicine as an astringent. It contains a tannic acid not quite like that of Galls, known as *querci-tannic acid*, which is common to other oaks and various plants. *Quercus alba* Linn., the American white oak, besides its excellent timber, supplies the White Oak Bark (*Quercus Alba*, U. S. Ph.) of our Pharmacopœia; composition probably the same as that of *Q. Robur*. Besides the tannin, many oaks, especially the darker ones, contain a yellow coloring matter, *quercitrin*, used in dyeing; *Q. coccinea*, var. *tinctoria* Alph. D C., our black oak, has been largely exported for this purpose. *Q. coccifera* Linn., is infested by a sort of *Coccus* (*Lecanium Ilicis*), the female of which, like that of *Coccus Cacti*, contains a large amount of cochineal, and is also used for scarlet dyes under the name Kermes. *Q. suber* Linn., the cork oak, supplies the world with that unique and indispensable substance, and, lastly, *Q. virens* Ait., the live oak, supplies the best of all timbers for ship-building. Of the other genera of this useful family the following may be mentioned: *Castanea vesca* Linn., the chestnuts, both European and American; *C. pumila*, the little chinquapin; *Fagus*, of several species, the beeches; and *Corylus*, hazel-nuts, birches, walnuts, and hickory-nuts are included by many botanists in the same family. *W. P. Bolles.*

NUT, HAZEL (*Noisette*, Codex Med.). The fruit of *Corylus Avellana* Linn.; Order, *Cupuliferæ*, is a common table-nut of no medicinal qualities; it contains a mild, agreeable *fixed oil*, which has been offered as a substitute for that of the cod, but has no further resemblance to it than all fixed oils have to each other. It is simply a non-nitrogenous food. The American hazel-nut, or filbert, *Corylus americana* Walt., is smaller than the above, but otherwise similar. (For the order, see the preceding article.) *W. P. Bolles.*

NUTMEG (*Myristica*, U. S. Ph., Br. Ph.; *Semen Myristicæ*, Ph. G.; *Muscade officinale*, Codex Med.). The seed, deprived of its outer coat, of *Myristica fragrans* Houttuyn; Order, *Myristicaceæ*.

Fig. 2520.—Branch of Nutmeg-tree, with Fruit. (Baillon.)

This is a small evergreen tree, twenty or thirty feet high, with smooth, grayish-brown, spreading branches and alternate, dark-green, oblong, pointed, entire leaves. The flowers are in small axillary racemes, of from two to four or five in each, and dicœcious. They consist of a greenish-yellow, bell-shaped calyx, about a quarter of an inch long and three-lobed at the border, and a column of six or eight coherent anthers or a single one-celled and simple, one-ovuled, superior ovary within, according to the sex. The fruit, about the size of a small pear, is a sort of drupe, with a fleshy pericarp, that splits longitudinally at maturity, exposing the single erect seed, partly covered with a brilliant-scarlet, fleshy, irregularly cleft aril. This seed, after the Mace and the dark-brown, brittle testa have been removed, is the Nutmeg. The Nutmeg-tree is a native of the Molucca and Banda Islands, and other parts of tropical Oceanica, where it is also cultivated, and from which it has been introduced into other tropical countries. The Nutmegs of commerce are from cultivated plants, and gathered and prepared with considerable care and some unnecessary fussiness. When the fruit is ripe, and has split open, it is plucked and the seed removed; then the aril is removed and dried as a separate article (Mace). The seeds are then dried for several weeks by a slow fire, and the shells broken off, after which they are generally either rubbed in powdered lime or soaked or washed in it, when they are ready for sale. This rubbing with lime is said to be a relic of the old Dutch method, to insure destroying the vitality of the seed before exporting it, to prevent the introduction of the trees to other countries. Unlimed Nutmegs are better than the limed, but are not often met with in this country. In the East, Nutmegs are even sold in the shell, which would seem to be a still better condition.

Fig. 2521.—Seed of the Same, surrounded by the irregularly cleft Aril (Mace); also, Longitudinal Section of the Seed. (Baillon.)

The early use of Nutmeg in China and India is extremely probable, although the references to it are rather doubtful. The first notice of its introduction into Europe is said to be about 1195 (Flückiger). It has been, until within the last hundred years, costly and rare, and used more for perfumery, and as an especial luxury, than as a cheap and common condiment.

Nutmegs need no description. The marbled appearance of the albumen is due to the deep and complicated involutions of the inner seed-coat. The same thing is seen in the areca-nut and a few other seeds.

Composition.—The most important constituents are a *fat*, often erroneously called Oil of Mace; a solid, yellowish-brown, fragrant substance, containing a peculiar fatty body, *Myristicin;* besides several common glycerides, and a little essential oil that gives it its odor. This fat occurs to about twenty-five per cent. in Nutmegs, and is a distinct article of commerce; being imported from Asia, where it is expressed from inferior and broken seeds. The second ingredient of interest is the volatile oil (*Oleum Myristicæ*, U. S. Ph.), of which from three to eight per cent. can be obtained by distillation.

Mace (*Macis*, U. S. Ph.) contains about eight per cent. of an essential oil, a little different in odor from that of Nutmeg; both are of corresponding composition, consisting of terpenes and oxygenated portions.

Uses and Action.—Both Nutmeg and Mace are used for the aromatic properties of their essential oils, and do not differ from the other spices in their medicinal properties. See Cinnamon.

Administration.—They can be administered in powder if desired. The former is an ingredient of the Aromatic Powder (*Pulvis Aromaticus*, U. S. Ph.) and of the Compound Tincture of Lavender (*Tinctura Lavandulæ Composita*, U. S. Ph.). Dose in substance from one-half to one gramme.

Allied Plants.—There are a few other species of *Myristica*, mostly Asiatic, a few of whose fruits have been used as Nutmegs, but they are not in the market now. The order contains only this genus.

Allied Drugs.—See Cinnamon. *W. P. Bolles.*

NUTRITION. By the term nutrition, employed in its broadest sense, is understood a series of processes by which the living organism, as a whole or its component

parts or organs, is maintained in its normal condition of life and growth. A study of nutrition in this wide sense would therefore include all of the steps by which nutritive matter introduced into the body becomes for a time incorporated with the different tissues and fluids, and is finally excreted from the body in different forms through the various excretory channels. Such an exchange of material between the organism and the external world is the means by which the various functions of life are performed. Thus nutrition is a complex process, involving a number of subsidiary processes; and as several of these have already been described under the heads of Absorption, Circulation, Digestion, etc., it will be the object of the present article mainly to consider the metabolic phenomena of the body—viz., such chemical transformations in living tissues as are classed under the term "metabolic;" *i.e.*, those chemical changes by which the material brought to the tissues and organs by the blood is transformed into other products through the activity of the living cells, with liberation of energy, prior to its excretion. This implies a comparison of the income and outcome, with an attempt to connect together, so far as may be, the alimentary matter and the excretory products; to trace out, as far as possible, the various steps or processes by which the former is changed into the latter. We have, moreover, to consider under this head the decomposition and exchange of material incident to varying conditions of the organism—the gain and loss—as well as the reasons for the metabolic changes or chemical decompositions characteristic of life.

All animal cells, whether single or united in tissues or organs, consume a certain amount of matter. The products of this consumption are, moreover, not the same for each organ or tissue; thus the liver has its special products, while those of the mammary gland are quite different. The matter to be consumed, however, is in all cases the same. The blood, with its content of nutritive matter, flows alike through all, and thus the different products resulting from the activity of the individual organs plainly indicate a difference in structure or in chemical function. Tangible evidence of chemical activity in the organs and tissues of the body is found in the fact that blood circulating through any living tissue or organ has a different composition on leaving the organ from what it had on entering. The tissues have the power of abstracting from and of giving to the blood, but the matters given up to the blood are quite unlike the matters abstracted. In other words, the nutritive material absorbed from the blood is changed, through the metabolic activity of the cells, into other substances, either more or less complex than the nutritive matter absorbed. Hence metabolism may be of two kinds—constructive or destructive. The former is termed anabolism; the latter, katabolism. As an example of the former, we have the gradual construction of the cell-protoplasm out of the matter brought by the blood; while the downward series of changes, in which complex bodies are broken down, with liberation of energy into simpler waste bodies, constitute katabolism, or are katabolic changes.

Not all of the matter, however, taken from the blood is returned to that fluid. Some of the products of tissue-metabolism enter instead into the glandular secretions, and thus ultimately leave the body altogether; as in the case of the glands of the alimentary tract, the kidneys, and the mammary glands. Other products, again, are retained for an indefinite time in the tissue—stored up, as it were—and then are finally given up, either in the same form or further modified. Adipose tissue constitutes a good example of the so-called storage-tissues. In muscle and nerve tissue, on the other hand, the products of metabolic activity are very soon cast into the circulating blood. In the liver, however, we have an organ whose complexity is manifest from the fact that it disposes of its metabolic products in all three ways—one portion being cast at once into the blood; a second portion temporarily deposited in the hepatic cells in the form of glycogen, and given up as occasion requires; while a third portion is poured into the intestinal canal in the form of bile, and after serving its purposes there, is cast out of the body.

Now, there are two ways of studying the metabolic phenomena of the body. One is to study the phenomena as manifested in the individual organs and tissues, constituting what may be termed special metabolism; the other is to study the phenomena collectively, constituting general or "total metabolism." The first method has for its object to trace out, step by step, the further changes of the digestive products after they have been absorbed by the tissues, prior to formation of the final excretory products. Many of these changes are, without doubt, intended merely to facilitate the removal of the waste products—the products of muscle-metabolism, for example—modifying them slightly, simply to increase their solubility or their absorption. Many of them, on the other hand, are the direct results of decided metabolic activity, by which simpler bodies are formed and energy is set free. All of them are of more or less interest. Study, therefore, of the metabolic changes in the single organs themselves is a prime necessity, but there are almost insurmountable difficulties in the way of exact quantitative study of the isolated organs. In a few instances we can locate the metabolic processes, and study them in more or less detail, but in the majority of cases it is impossible. We are therefore obliged to look to the metabolism of the body as a whole for data to make clear the changes which the various alimentary principles undergo, after their absorption into the blood. This, which may be termed the statistical method, consists in a comparison of the income with the outcome, by which deductions may be drawn concerning the changes which take place in the various tissues and organs while the former are being converted into the latter. Further, the real income must be distinguished from the apparent one by the subtraction of the faeces; for the greater part of the latter is undigested matter or food, which, though placed in the alimentary canal, has not really entered into the body. But before such deductions can be fairly drawn, we need to know all that it is possible to know concerning the special metabolism of the individual parts. At the same time it must be remembered that only by a study of the total metabolism of the organism do we obtain a correct idea of the influence of the various conditions to which the body may be exposed, of the way in which the exchange of material takes place, and to what extent and in what manner any particular alimentary principle causes a gain or loss to the body.

General Statements concerning the Income and Outcome, together with Methods for determining the Composition of the Same.—Since all vital processes have their origin in the energy liberated by the chemical decompositions going on in the organism, it follows that a study of these decompositions may, to a certain extent, constitute a means of measuring the amount of metabolic activity; and since there is a direct connection between the decomposition products and the nature of the material employed, it follows that by studying the former we can acquire, to a certain extent, by comparison with the income, a fairly accurate idea of the consumption of material by the organism. Further, this may be expressed, not only in amounts of the individual elements, but also in amounts of the various alimentary principles; and it is, moreover, possible to draw more or less accurate deductions as to the successive changes which the individual chemical compounds undergo before leaving the body. It is thus very evident that great accuracy is needed, both in the analysis and in the collection of the excreta, to have the comparisons of any value; errors must be reduced to a minimum, otherwise false results may be obtained owing to the magnifying effects of the necessary computations. It follows from this, also, that only large organisms can be used in the study of total metabolism, since in small animals the outcome would be too limited for accurate work.

The normal excretory products—viz., those end-products of metabolic activity which are of no further use to the system—are removed from the body through four channels: the kidneys, intestines, lungs, and skin. Ordinarily, in determining the consumption of matter by the body, it is only necessary to consider the excretions from

these four places, since by far the greater part of the loss sustained by the body takes place through these channels. The body loses, however, considerable matter which does not come wholly from decomposition and which cannot ordinarily be considered as a measure of metabolic activity—as the water of the urine, the ash of the urine and fæces, etc. Further, there is a considerable loss of matter through the milk, saliva, nasal mucus, hair, etc.; but only in exceptional cases is it necessary to consider these. As a rule, the gaseous waste products are excreted through the lungs and skin—the soluble solid bodies through the kidneys, the insoluble through the intestines. The gaseous products are mainly carbonic acid and water—for the most part, products of oxidation, though the water may be, to a certain extent, the result of simple evaporation; occasionally other gases, as hydrogen and marsh gas, are present, formed in the intestinal canal by fermentation. The more important bodies excreted through the kidneys are urea, uric acid, creatin, creatinin (all nitrogenous), phosphates, sulphates, and chlorides of calcium, magnesium, potassium, and sodium, while by the intestines is excreted the excess of food undigested, together with the undigestible matter and the insoluble products resulting from the combined action of the bile and the intestinal secretions.

These products together constitute the outcome under normal conditions. In special cases it is frequently necessary to determine the individual bodies in the outcome, as urea, uric acid, etc., in the urine; but as a general rule the elements alone are determined, as nitrogen, carbon, hydrogen, sulphur, and phosphorus. Nearly all of the nitrogen excreted is contained in the outcome from the kidneys and intestines, though traces may be contained in the perspiration and in the breath. The carbon and hydrogen, on the other hand, are excreted mainly through the lungs and skin, a proportionally small amount only being removed through the fæces and urine. The remaining elements—sulphur and phosphorus, together with chlorine, potassium, sodium, iron, lime, and magnesium—the latter of which need to be taken into account only in special cases, are found mainly in the urine and fæces.

In experimenting on the loss of matter in animals or human beings, it is necessary that the excretions be examined for a definite length of time, in order to have the results of any value, which time must be at least twenty-four hours. A determination of the percentage amount of nitrogen, for example, contained in a sample of urine gives no indications whatever of the amount of nitrogen excreted from the organism during the entire day, nor is it possible from such data to draw deductions as to the amount of nitrogenous matter consumed by the system during the twenty-four hours. Neither is it allowable to measure the amount of carbonic acid exhaled in two hours, and then multiply the result by twelve, in order to obtain the amount exhaled during the entire day. The conditions are so liable to variation that the results of one hour's observations can in no wise be taken as an index of the next hour. Where it is desired to study the influence of any particular agent upon total metabolism, or to study the results of any particular condition, it is necessary to continue the observations for twenty-four hours or longer, the results as to outcome being expressed in grams per diem. The reasons for this are quite obvious, when we remember that digestion may not be finished under six or eight hours, and that the fæces coming from any particular diet may not make their appearance before ten hours; and thus, in following the effect of any particular food day after day, the last food must be given at least twelve hours before the end of the experiment in order to obtain all of the outcome. And in the case of herbivorous animals, with their more complicated digestive apparatus, the reasons are still more obvious for extending the time even to several days. It is plain, then, that twenty-four hours at least are required before the body can be assumed to have reached its former condition, comparable to that at the beginning of the experiment; and hence all of the excretions of that twenty-four hours must be collected and examined for comparison with the income. With a carnivorous animal, where a single feeding only is required, twenty-four hours is undoubtedly sufficient for complete digestion, and for the excretion of the metabolic products.

In the collection of the intestinal excretions we need, many times, some definite way of determining with accuracy whether the fæces excreted in a given time come wholly from the food given, and also whether all of the fæcal matter has been obtained from a definite amount of food. This is easily accomplished by giving, eighteen to twenty hours before the feeding-experiment, a considerable quantity of some substance, like powdered bone, easily recognizable in the fæces by its light color; and in a series of different feeding-experiments with the same animal, the fæces coming from each particular diet can be sharply separated by the giving, at proper times, of some such inactive substance. Many times, however, the food given on different days is so different in its nature as to be itself easily recognized in the fæces. Again, it must be remembered that in experiments of this kind, where it is desired to study the influence of any agent on the consumption of matter by the body, the organism prior to the experiment must be in a definite condition—either that of hunger, where like quantities of material are decomposed each day, or else in a condition of equilibrium, in which the real income and outcome balance each other and the decompositions remain constant in their nature.

In all feeding experiments the composition of the income is equally important; but, aside from exceptional cases, individual analysis of each food is not absolutely necessary, since the purified products frequently used have an almost constant composition, as pure blood-fibrin, egg-albumin, sugar, starch, fat, powdered meat extracted with water, inorganic salts, or various mixtures of the above. Even where experiments are continued for a long time, and where it is desired to use more appetizing foods—as fresh beef for carnivorous animals, or cereals in the case of herbivorous animals—general estimates can be made, based on the average composition of the material, which in many cases are sufficiently accurate for general work, the possible variations being only within narrow limits. Thus Voit[1] gives the average composition of lean beef as 75.9 per cent. water and 3.4 per cent. nitrogen. That the latter figure does represent the average amount of nitrogen in lean beef is evident from the results of Huppert,[2] Grouven,[3] and others. Still, it is much more satisfactory, in every case where the experiments are of any value, to have the income accurately determined, instead of relying on general estimates; particularly as it is more common to use the food-stuffs in feeding-experiments than the pure alimentary principles. As a general rule, the amount of nitrogen in a substance from the animal kingdom can be safely taken as an index of the amount of albuminous matter present. Taking 16.00 as the average percentage of nitrogen in albuminous substances, the factor 6.25 can be employed to multiply the nitrogen found, for an estimate of the proteid matter. In the vegetable kingdom, however, the albuminous substances vary considerably in their content of nitrogen, but Ritthausen[4] has shown that with most of the cereals and legumins the factor 6 gives fairly accurate results (16.6 per cent. nitrogen). Another very important point regarding the content of nitrogen in vegetable substances is that all of the nitrogen is not present in the form of albuminous matter, but in some cases quite a little exists in the form of amides[5] (asparagin, glutamin, etc.); a point very essential to know in determining the nutritive value of a food.

The methods used in determining the chemical composition of the income and outcome are to be found in books on chemistry.

Excretion of Nitrogen.—The nitrogenous excreta are mainly removed from the body through the urine and fæces, the greater portion through the former channel. In determining the amount of nitrogen in the urine, the first point of importance is the collection of the entire quantity for each day; the loss of any portion, however slight, of such a concentrated fluid would be detrimental to an accurate result. A small portion of the urine excreted

in the twenty four hours suffices for the determination of nitrogen. Frequently instead of total nitrogen, the urea, which is the main product of nitrogenous metabolism, is determined by either Liebig's (as modified by Pflüger[6]) or Hüfner's method. The nitrogenous bodies found in the intestinal excretions have quite a different origin and therefore quite a different significance, from the nitrogenous excreta of the urine. In the intestinal excretions are to be found, naturally, such of the food as was unabsorbed, together with the non-diffusible residues of the digestive fluids and the epithelium and mucus from the lining membrane of the alimentary tract. Mixed with these, however, is a small amount of true metabolic products, cast directly from the surface of the epithelium cells. To separate these products from the far greater mass of refuse is a difficult matter, the difficulty of which is greatly increased in the case of herbivorous animals with their larger excretions. The quantity of fæcal matter excreted by carnivorous animals is quite small, and the nitrogen correspondingly small; thus in dogs of about eighty pounds avoirdupois, ten grams of dry fæces are excreted per day, on an average, with a content of 650 milligrams of nitrogen.[7] In the case of human beings on a mixed diet the amount is much larger, and in herbivorous animals much larger still, so that the amount of nitrogen excreted by the fæces may be, in some cases, even greater than that excreted by the urine.[8] In carnivorous animals, excepting where large excess of food is taken, the greater portion of the nitrogen excreted in the fæces is probably in the form of metabolic products; in the urine the entire amount of nitrogen represents metabolic activity.

If the nitrogen excreted from the body is removed mainly by the urine and fæces, it follows that the sum of the nitrogen contained in these two excretions ought to equal, or nearly so, the nitrogen of the food. By the older writers[9] it was considered that there was a large deficiency of nitrogen in the urine and fæces, amounting in many cases to from thirteen to fifty per cent., from which it would appear that a large amount of nitrogen must be excreted in either the perspiration or breath, or perhaps in both.

More careful experiments by Bidder and Schmidt,[10] on carnivorous animals, gave evidence of only two to three per cent. deficiency in the urine and fæces. Voit,[11] however, by the use of improved methods, obtained far closer results, in which the deficiency amounted only to fractions of one per cent. Other investigators obtained similar results, notably Ranke, Kühn, Meissner, Henneberg, and Peligot,[12] the experiments being conducted on men, dogs, cats, oxen, cows, horses, birds, and sheep. It is obvious that great precautions must be taken in the choice of accurate methods; and, moreover, the animal experimented upon must be supplied with large quantities of proteid matter (meat, if carnivorous), in which case so-called nitrogenous equilibrium is quickly established. Insufficent proteid matter would tend to produce an apparent deficiency of nitrogen, as in such cases a long-continued accumulation, or addition to the body, may take place. The following experiment by Voit illustrates the nature of the results obtained by later workers:

Experiment extending over a Period of Twenty-three Days.

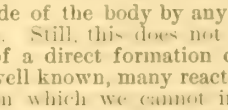
		Grams Nitrogen	
34.5[00] grams flesh fed		1173.0	
Found	in the urine	1163.5	= 1176.9
	in the fæces	13.4	
Difference		+ 3.9 = 0.3 per cent.	

A few physiologists still believe in the excretion of nitrogen by other means than through the urine and fæces; thus Seegen and Nowak[13] claim to have found an increase of nitrogen in the air supplied to an animal in a confined chamber, oxygen being continually supplied and the waste products removed; the gain to the air being, on an average, 6.5 milligrams of nitrogen per hour per kilo of body-weight. Gruber,[14] however, in 1880, carried on several series of experiments to substantiate Voit's views, and obtained, by experimenting on dogs, under the most carefully guarded conditions, a complete verification of Voit's results.

Pettenkofer and Voit,[15] likewise, by more direct experiments, showed the probable incorrectness of the views held by Seegen and Nowak, since, for example, a dog weighing 3 kilos (6.6 pounds avoirdupois), enclosed for three days in a chamber supplied with pure air, and fed with meat, milk, etc., gave up to the air during that period of time but 41 milligrams of ammonia = 34 milligrams of nitrogen. Undoubtedly a small amount of nitrogen may be excreted through the breath in the form of ammonia. Moreover, a small amount of nitrogen is continually being lost through the epidermal or keratin-producing tissues, which may become somewhat pronounced in the case of animals with much hair or wool, as sheep.[16]

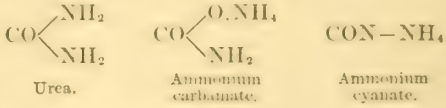
As already stated, urea is the form in which the greater part of the nitrogen is excreted in the urine. It becomes, then, an interesting point to trace out the formation of urea, to understand, if possible, the nature of the regressive metamorphosis by which proteid matter is changed into the ultimate product, urea. In studying this question we need to know, first, whether urea originates wholly or in part directly from albumin, or indirectly through the medium of a series of intermediate bodies; second, whether food-albumin, as such, is convertible into urea or whether it must first become organized, *i.e.*, become a part of a living cell before it can be decomposed; third, where the formation of urea takes place, whether in the kidneys, liver, or other organs, or in the tissues of the body generally.

In answer to the first question, we know that as yet chemists have not been able to form urea from proteid matter outside of the body by any of the usual methods of oxidation. Still, this does not in itself exclude the possibility of a direct formation of urea by oxidation, since, as is well known, many reactions take place within the organism which we cannot imitate outside of the body. There are, however, chemical reasons why such a view of the formation of urea cannot be accepted. In this connection it is interesting to note that Lossen[17] has demonstrated that a body formed in the oxidation of albumin by potassium permanganate, and formerly supposed by Bechamp[18] and Ritter[19] to be urea, is in reality guanidin, a body similar to urea in its chemical constitution:



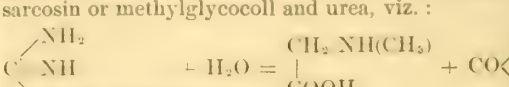
Urea. Guanidin.

While urea itself has never been formed directly from albumin outside the body, cyanogen compounds are common products of proteid decomposition, and these are easily convertible into urea; likewise ammonium carbamate, also easily convertible into urea.



Urea. Ammonium carbamate. Ammonium cyanate.

These latter facts lend favor to the view that urea originates not directly from albumin, but from intermediate bodies, and this view is still further strengthened by the fact that in muscle and nerve-tissue, the two pre-eminently metabolic tissues of the body, creatin occurs in large quantity, out of all proportion to the small amount of creatin excreted daily through the urine. Hence the greater part of the creatin must leave the body in some other form. Now, the most notable reaction of creatin is its decomposition by various agents into sarcosin or methylglycocoll and urea, viz.:



Creatin. Sarcosin. Urea.

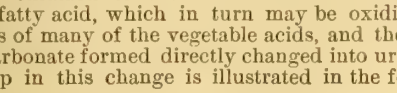
Hence, it seems a very plausible supposition that the creatin formed in the muscle and nerve-tissue is a nat-

ural antecedent of urea; that, being carried by the blood to the kidneys, it is picked out, as it were, by the epithelium cells and then transformed into urea. That such is the case, however, cannot be accepted as a settled fact. Many other known facts point to the possibility of urea being formed through the intermediate amido-bodies. This view is firmly held by Schultzen and Nencki. It is a fact well known, and many times verified, that albumin by a series of processes, such as boiling with dilute acids and alkalies, or by the action of the pancreatic trypsin,[20] is convertible in part into a number of amido-acids, such as leucin or amidoisocaproic acid, tyrosin or oxyphenolamidopropionic acid. In a similar manner, the collagenous matter of connective tissue[21] is decomposable into leucin and glycocoll or amido-acetic acid.

Tyrosin. Leucin. Glycocoll.

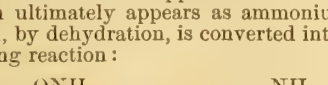
The constitutional formulæ of these three bodies indicate at once that glycocoll, for one, might be easily convertible into urea, and the recent feeding experiments on dogs by E. Salkowski[22] show that more or less glycocoll is changed into urea. Moreover, Schultzen and Nencki[23] have shown that leucin, as well as glycocoll, is converted into urea within the body. This harmonizes with the known increase of urea attendant upon increased proteid diet, since leucin is a normal product of the pancreatic digestion of proteid matter. Again, the direct introduction of leucin into the alimentary canal is followed by an increased excretion of urea, no leucin whatever being found in the urine.

It is difficult to trace out, however, the way in which urea can be formed from leucin. The constitution of the body throws no light on this subject. The suggestion, however, has been made that the amido-acid may suffer the same change as takes place in putrefaction, viz., be oxidized to the ammonium salt of the next lowest fatty acid, which in turn may be oxidized, like the salts of many of the vegetable acids, and the ammonium carbonate formed directly changed into urea. The first step in this change is illustrated in the following equation:



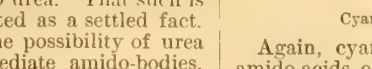
Leucin. Ammonium valerate.

This at once suggests a notice of the so-called "anhydride theory," in which it is supposed[24] that the nitrogen from albumin ultimately appears as ammonium carbonate, and then, by dehydration, is converted into urea, as in the following reaction:



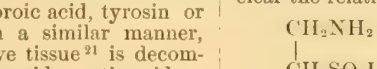
E. Salkowski,[25] however, found that by feeding dogs with ammonium chloride the greater part of the salt was excreted unchanged; with rabbits, on the other hand, the result was quite different, the ammonia of the salt entirely disappearing, while its nitrogen showed itself in a corresponding increase of urea. That the urea did not originate from albumin is plain from the fact that the excretion of sulphur showed no increase. Direct proof of the conversion of ammonia salts into urea has been obtained by v. Schroeder,[26] who, on forcing blood together with a little ammonium carbonate through the liver of a dead dog, with all necessary precautions, found a very decided increase of urea.[27] This experiment likewise indicates the possibility that the formation of urea takes place in the liver.

There are still other possible ways in which urea can be formed. Thus, Hoppe-Seyler[28] believes that urea is formed from cyanic acid and ammonia; and it is well known that in the decomposition of albumin, cyanic acid and cyanamide both result, and then, by the addition of ammonia, urea would naturally be formed.



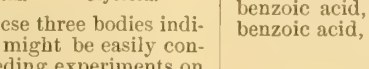
Cyanic acid. Urea.

Again, cyanic acid brought in contact with various amido-acids outside the body gives rise to the formation of uramido-acids, which are simply substituted ureas. Thus E. Salkowski[29] has found in the urine of men and dogs, after feeding to them taurin, a constituent of bile, uramidoisathionic acid. The following formulæ make clear the relationship between these bodies.



Taurin. Cyanic acid. Uramidoisathionic acid.

In this complex body the urea is easily recognizable. Another similar and likewise very important reaction, discovered by Salkowski,[30] is the formation of uramidobenzoic acid, present in the urine after feeding amidobenzoic acid, a derivative of tyrosin.



Amidobenzoic acid. Uramidobenzoic acid.

Further, it is possible to form uramido-acids outside of the body by simply melting the amido-acid with urea. While these facts cannot be held as a proof of the presence of cyanic acid in the body, still they have been used as an indication of that.

These are the more important theories current at present concerning the formation of urea, and while we can accept none of them as actual facts, except in so far as the experiments themselves are concerned, yet all of the reactions are exceedingly important as pointing out the close relationship in constitution between several of the nitrogeneous digestive products and the metabolic product, urea. Indications certainly point to a reconstruction of urea, under certain conditions, out of the "ammonia phase;" taking this for granted, the question then resolves itself into whether the whole of the nitrogen of urea is obtained through the form of ammonia by the dehydration of ammonium carbonate, or whether it comes only partially from ammonia, as in the dehydration of ammonium carbonate or in the union of ammonia with some body containing the cyanogen radical. Just here it is interesting to note that urea or carbamide is a much more stable body than ammonium cyanate, and in the change of the latter into the former energy is liberated. Moreover, Pflüger[31] is of the opinion that the ready decomposition of living protoplasm is due to the presence of the cyanogen group. Thus the decomposition products, urea, uric acid, and others of regressive metamorphism, notably creatin, guanin, etc., are never obtained artificially from albumin. These latter bodies contain the cyanogen radical, and Pflüger argues that living albumin contains the greater part of its nitrogen, in the form of CN and not NH_3, none of the decomposition products containing the former group having ever been obtained from dead albumin. Thus, in the formation of living protoplasm from food-albumin, a change is effected in which the nitrogen atoms pass into cyanogen compounds, and, on the death of the protoplasm, again return to the more stable condition of amides.

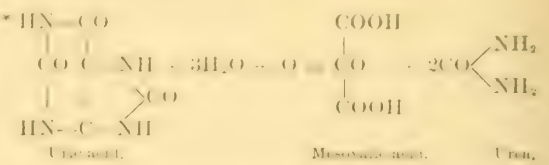
We come now to the second point, viz., whether food-albumin first becomes organized before it is decomposed into urea. After eating a large diet of meat the amount of urea in the urine is at once increased. Panum[32] has found, in the case of a dog, that at the end of seven or eight hours after the meal fully half of the urea, corresponding to the nitrogen taken in the food, is excreted. And it hardly seems probable, as Voit remarks, that digestion, absorption, organization, and, finally, decomposition of the protoplasmic matter of the cell could take place within so short a time. Neither does it appear plausible that both the construction and destruction of the cells should be proportional to the amount of albu-

min eaten. On the other hand, it is not to be understood that the decomposition of albumin takes place in the blood, but rather that the albumin is carried by the circulating blood to the organs and tissues, and there in immediate contact with the cells, in the albuminous plasma with which the cells are surrounded, the decomposition takes place. Neither, on the other hand, is it to be understood that the cells are absolutely stable. On the contrary, Voit considers that about one per cent. of the albumin constituting any particular organ is lost daily under the conditions of the decomposition. This loss is naturally covered up by the albumin of the food, and to that extent a small portion of the food-albumin becomes organized before its decomposition into urea.

We come now to the third point, viz., in what particular part of the body is urea formed? Or is it a process which goes on in all parts of the body? Certainly, as Salkowski and Leube[34] remark, if we admit the direct formation of urea from albumin without any intermediate products, the kidneys in this particular case can be nothing more than excretory organs. On the other hand, no one would consider it possible that the entire decomposition of albumin could take place in the kidneys. Thus the question practically resolves itself into whether the kidneys have the specific power of transforming the amido-acids, ammonium carbonate, or other intermediate products into urea, or whether the change of the above products into urea takes place in the tissues, and the kidneys are simply the agents to pick out from the blood the urea present there. W. v. Schroeder,[35] by forcing blood containing ammonium carbonate through the kidneys of a dog, and also of an ox, found that no conversion of the ammonium salt into urea took place; while similar experiments with the liver of a dog showed a very marked formation of urea. The same investigator has also verified the oft-quoted statement that extirpation of the kidneys is followed by an accumulation of urea in the blood.[36] This would apparently indicate the entire lack of any formation of urea in the kidneys. Oppler[37] and Zalesky, however, have found that after ligaturing the ureters of a dog, the amount of urea in the blood is greater than on removal of the kidneys, and they therefore conclude that a small portion of the urea, at least, may be formed in the kidneys. This view has, however, been strongly contested. And the fact that the injection of urea into the blood is followed by a rapid secretion of urine, lends favor to the view that the renal epithelium simply picks out the urea and carries it into the channels of the tubuli.

Assuming, then, that urea has its origin in the tissues, we should naturally expect to find more or less of it there; and, indeed, it is regularly found in the liver, spleen, lungs, and brain, but never in the muscles.* The most plausible theory, therefore, is that urea has its origin in the large glandular organs, viz., the liver and spleen. The liver, particularly, is rich in urea, and frequently contains more than the blood, and Frerichs has found that in acute atrophy of the liver, where the hepatic cells lose their functional activity, urea disappears almost entirely from the urine, and what is also of importance, leucin appears in its place. We might, therefore, fairly reason that urea is formed in the hepatic cells of the liver from various intermediate substances, of which leucin may be considered as one.

Of the remaining nitrogenous bodies excreted in the urine, uric acid, hippuric acid, creatinin, and the xanthin bodies are the more important; the latter are, however, present only in very small quantity. Uric acid in some animals, as birds and reptiles, entirely replaces the urea. It is, however, a less oxidized product of proteid metabolism. The amount of uric acid excreted in twenty-four hours by a healthy man varies from 0.4 to 0.8 gram in cases where the excretion of urea ranges from twenty-five to forty grams; the relative proportion being as one to sixty, or as one to fifty. By the oxidation of uric acid, two molecules of urea are formed, together with one molecule of mesoxalic acid, but experiments tend to show that instead of being an antecedent of urea, uric acid is rather the product of a metabolism slightly different from that which leads to urea (Foster).



Still, the experiments of Wöhler and Frerichs,[38] as well as those of Neubauer,* tend to show that a portion of the uric acid taken in food by carnivorous animals is oxidized to urea, and the same is doubtless true of the uric acid formed in the body. The formation of uric acid among the mammalia is thought by Ranke[40] to take place in the spleen, and in support of this view he states that uric acid is found in increased quantity in the urine in those diseases which are accompanied with swelling of the spleen; and it is noticeable, also, that the amount of acid excreted appears to run parallel with the turgescence. Moreover, the excretion of uric acid increases a few hours after eating, at a time when the spleen is most turgid with blood. Short fasts, on the other hand, diminish its excretion. The formation of uric acid from proteid matter is, doubtless, a direct process, xanthin being first formed, and this body by simple oxidation changed into uric acid:

$$\underset{\text{Xanthin.}}{C_5H_4N_4O_2} + O = \underset{\text{Uric acid.}}{C_5H_4N_4O_3}$$

This view is supported by the fact that uric acid and the xanthin bodies frequently replace each other in various organs of the body in disease, as also in the urine. Moreover, nuclein, a semi-phosphorized albuminous body, yields both xanthin and hypoxanthin[41] on digestion with gastric juice and also with pancreatic juice; uric acid itself, however, has never been formed by chemical means directly from proteid matter. Again, Salomon[42] has found that in the decomposition of vegetable albumin in germinating seeds, hypoxanthin ($C_5H_4N_4O$) is formed.

In the hen, an example of animals where uric acid replaces urea in the urine, Knieriem[43] has found, by feeding experiments, that the amido-acids, glycocoll, leucin, etc., which in mammals are probably antecedents of urea, are here antecedents of uric acid. Knieriem, however, could not find that the ammonia of ammonium chloride was convertible into uric acid; but Schroeder[44] found that when ammonium carbonate was fed, then the nitrogen of the ammonia appeared in the urine as uric acid. Moreover, Meyer and Jaffe[45] found that urea in the organism of birds was converted almost wholly into uric acid, and it is thus assumed that in birds and reptiles the uric acid formed does not come directly from the decomposition of albumin, but is a product of synthesis, which process takes place generally throughout the tissues of the animal. In this connection it is interesting to note that J. Horbaczewski[46] has recently succeeded in making uric acid synthetically by heating together glycocoll and urea.

Hippuric acid almost entirely replaces uric acid in the urine of the herbivora. The main source of hippuric acid in herbivorous animals, and to a certain extent in carnivorous animals also, is to be found in the food. Hippuric acid is a conjugate body made up of benzoic acid and glycocoll; the latter is always present in the body, coming from the decomposition of albuminous and collagenous matter, and whenever benzoic acid or any substance containing the benzoic acid radical is introduced into the stomach it appears in the urine as hippuric acid.

$$\underset{\text{COOH}}{\overset{|}{CH_2NH_2}} + \underset{\text{COOH}}{\overset{|}{C_6H_5}} = \underset{\text{COOH}}{\overset{|}{CH_2NH{-}C_6H_5CO}} + H_2O$$

Glycocoll. Benzoic acid. Hippuric acid.

* Demant (Zeitschrift für Physiolog. Chem., ix., p. 419) has, however, recently claimed the presence of urea in the muscle, but this needs verification before it can be accepted as a settled fact.

* Formula of medicus.

Meissner and Shephard[47] have demonstrated that the fodder, as hay, of herbivorous animals contains a substance with the benzoic residue, and that when this substance is withdrawn from the food, hippuric acid disappears from the urine. In carnivorous animals, also, the amount excreted (0.2 to 2 grams) depends somewhat upon the nature of the food; still, in this class of animals hippuric acid does undoubtedly represent to a certain extent decided metabolic changes, having its origin, in part, in the decomposition of proteid matter. Thus Salkowski[48] has shown that in the putrefaction of albumin under the influence of the pancreas, in addition to other products there is formed an aromatic acid, phenyl-propionic acid,

$$\begin{array}{l} CH_2\,C_6H_5 \\ | \\ CH_2 \\ | \\ COOH \end{array}$$

a homologue of benzoic. Salkowski has, moreover, found that this acid fed to rabbits and dogs appears in the urine as hippuric acid; and as Kühne and Nencki have both found that putrefactive processes go on in the intestines of living animals, it is very probable that we have here one source of the benzoic acid residue, and that this body being absorbed is oxidized to benzoic acid, and then meeting with glycocoll is excreted as hippuric acid. As to where the synthetical formation of hippuric acid takes place in the human organism, we have no decisive information. In dogs, however, Bunge and Schmiedeberg[49] have plainly demonstrated that when the kidneys are extirpated, or the renal vessels ligatured, benzoic acid is no longer converted into hippuric acid; but, on the other hand, when the ureters are ligatured, then hippuric acid accumulates in the tissues. That the synthesis takes place in the kidneys has been further verified by forcing blood containing equivalent amounts of sodium benzoate and glycocoll through fresh kidneys, directly after their removal from the body. Over half a gram of hippuric acid was formed in six hours. Kochs[50] has, moreover, proved the formation of hippuric acid in small quantity by warming together, at 40° C., blood containing benzoic acid and glycocoll with pieces of finely divided kidney. Similar experiments with pieces of liver gave negative results. It would appear, however, from the experiments of Salomon,[51] that the formation of hippuric acid is not confined to the kidneys in all animals. Thus in the rabbit, after extirpation of the kidneys, Salomon found hippuric acid in the blood, muscles, and liver, in noticeable quantities, after feeding benzoic acid.

It is in the form of these three bodies—urea, uric acid, and hippuric acid—that nitrogen is mainly excreted by the urine, and since in the case of carnivorous animals on a flesh diet, only about one per cent. of the nitrogen excreted in the fæces (often much less) exists there in the form of metabolic products, these three nitrogenous bodies of the urine, or the collected nitrogen of these bodies, must necessarily represent the total amount of nitrogenous matter decomposed within the body; and consequently, in the majority of cases, the loss of nitrogen from decomposition within the organism is to be measured by determination of the nitrogen in the urine.

Excretion of Carbon, Hydrogen, and Oxygen.—These three elements, unlike nitrogen, are mainly excreted as gaseous products, carbonic acid and water, through the lungs and skin—only a proportionally small amount appearing in the urine and fæces as solid nitrogenous or non-nitrogenous bodies. The amount of carbon and hydrogen in these latter can be easily determined by organic analysis, but the main measure of the absorption of oxygen, and the excretion of carbonic acid and water is to be found in a study of the respiratory products. This is accomplished by means of a respiration apparatus, constructed on the principle of Regnault's and Reiset's, or on that of Pettenkofer's.[52] The latter is by far preferable, being larger and better adapted to controlling the conditions necessary for successful work, though the other forms of apparatus,* being smaller and less complicated, are capable of yielding more accurate results in short experiments; and, as a rule, the latter apparatus has been used only to study the consumption and expiration of gases, irrespective of general metabolism. The accuracy of the larger Pettenkofer apparatus has been tested by Stohman[53] at Leipzig, by Henneberg,[54] and by C. and E. Voit and Forster.[55] The apparatus consists, essentially, of an air-tight chamber, sufficiently large to hold a man, with ample space for free motion. Pure air, measured by a gasometer, can be forced through the apparatus, thus giving a continuous supply of oxygen. By analyzing measured portions of the outgoing air the amount of carbonic acid and water given off by the occupant of the chamber can be easily determined for any length of time under varying conditions.

What deductions can be drawn from an estimation of the amount of oxygen absorbed and the amounts of carbonic acid and water excreted through the skin and lungs? Certainly, measuring the carbonic acid given off by the lungs and skin does not give a correct idea of the total amount of carbon involved in the daily decomposition, since a portion of the latter is excreted through the urine and fæces; neither does the amount of oxygen consumed and the amount of carbonic acid given out constitute a measure of the decomposition of non-nitrogenous matter, since albuminous matter by its oxidation necessitates the consumption of oxygen and the production of carbonic acid. Consequently, a determination of the total daily excretion of carbon constitutes simply a measure of the amount of carbon consumed by the body, which carbon, so far as any respiration experiment alone would show, might come from either albumin, fat, or carbohydrate.

From the amount of nitrogen in the excreta the exchange of albuminous matter is quantitatively ascertained, and knowing this it is easy to calculate the amount of carbon involved. If, now, with an exclusively proteid diet, the amount of carbon excreted corresponds in amount to the carbon contained in the albumin decomposed, why, then, proteid matter is the only material decomposed. If, on the other hand, more carbon is found than is contained in the decomposed albumin, then some non-nitrogenous carbonaceous substance of the body must have been decomposed (Voit). Excess of carbon under these conditions, like in the condition of hunger, has its origin in the decomposition of stored-up fat, for Pettenkofer and Voit[56] have shown, by experiments on dogs, that during hunger albumin and fat alone are decomposed, since the nitrogen excreted calculated to albumin, and the excess of carbon calculated as fat, made a total for the combustion of which the theoretical amount of oxygen required equalled the amount of oxygen actually consumed. The only other substance in addition to fat which could come into account would be the glycogen in the liver and muscle, and this, as Voit remarks, is present in too small quantity; although in the period just after digestion the amount of this intermediate body is doubtless considerable.

If, now, the amount of carbon in the excreta falls below the carbon of the food, it must, of course, have been stored up in the body and in the form of fat. If fat itself had been fed, the source of the stored-up fat would be obvious; if carbohydrate or albumin alone had been fed, then we must assume the formation of fat from each of these materials, if, in the case of proteid food all of the nitrogen fed be found in the excreta. If, on the other hand, a mixture of fat and albumin is fed, the carbon lacking must have been appropriated from either the fat or the albumin; in the latter case the fat consumed must have been decomposed, and then, from the decomposition of the albumin, fat must have been formed and retained by the body (Voit). That the carbon thus retained by the body is stored up as fat, and not in the form of some carbohydrate material, as glycogen or sugar, is evident from the work of Pettenkofer and Voit,[57] who have demonstrated in a long-continued experiment on a dog that the accumulation of carbon, calculated as sugar, would

* A form of apparatus similar in principle to Regnault's is in use at Pflüger's laboratory in the Physiological Institute at Bonn (Pflüger's Archiv, xiv., p. 78).

have amounted to nearly two thousand grams, an amount of sugar never present in the body of this animal. Other deductions to be drawn from the absorption and excretion of carbon under varying conditions will be referred to later.

Excretion of Sulphur and Phosphorus.—The only way in which these two elements are removed from the body to any extent, is through the urine and fæces, and mainly in the form of salts of sulphuric and phosphoric acids in the urine. Phosphorus is mainly taken into the body in the form of phosphates of the alkalies and alkali earths, though a small amount is present in the form of organic compounds, as lecithins and nucleins. With albuminous matter, moreover, there is always present a small amount of closely attached phosphates, and Bischoff [58] has found that in a hungry animal the excretion of nitrogen and phosphoric acid in the urine is in the proportion of 6.4 : 1 ; showing that in the decomposition of proteid matter the phosphoric acid combined with the albumin, becomes free. It is also interesting to note that this proportion is nearly the same as is found between the nitrogen and phosphoric acid of the muscles (7.6 : 1). It is quite probable, however, that the relative proportion of excreted nitrogen and phosphoric acid depends greatly upon the nature of the food, and will thus vary under varying conditions ; doubtless, some of the phosphoric acid excreted, as in hunger, comes from the decomposition of bone-tissue. Further, it is probable that in the metabolism of nerve tissue incidental to mental activity or other nervous action, there is a decomposition of the brain lecithin, with formation of phosphoric acid, which may appear in the urine. That such a decomposition is quite possible is evident from a study of the constitution of lecithin, which is built up on the type of glycero-phosphoric acid :

$$C_3H_5\begin{cases} O.C_{16}H_{31}O \\ O.C_{18}H_{33}O \\ O.PO-OH \\ \quad O.C_2H_4(CH_3)_3N.OH \end{cases}$$

Oleo-palmityl lecithin.

That such metabolism, however, has much influence on the total amount of phosphorus excreted appears improbable when we consider the amount of phosphorus contained in the entire nerve substance as compared with that in the muscles or bones.

Sulphur, which enters the body as a constituent element of the albumin molecule, and in the form of sulphates, is excreted mainly by the urine ; not, however, wholly in the form of sulphuric acid, but partially as complex sulphur compounds. Some little sulphur leaves the body by the fæces ; in the case of a dog fed on 1,800 grams of flesh, 3.4 per cent. of the sulphur taken in was so excreted. A portion of this sulphur, without doubt, represents simply a small residue of undigested albumin, but a portion also comes from the taurin of the bile. Voit has compared the excretion of sulphur with the daily income, and found a close agreement, and the same investigator has further found that the excreted sulphur, together with the nitrogen, may be taken as a measure of proteid consumption, and sometimes a comparison of the amount of sulphur and nitrogen serves to show whether the nitrogen excreted has its origin in sulphur containing albumin, or in some nitrogenous substance free from sulphur.

Of the sulphur compounds occurring in the urine, indican, or potassium indoxylsulphate is the most interesting. This body, which is present in normal urine only in small amount (6.6 milligrams to 1 litre of urine) is the source of the indigo bodies always obtainable from normal urine in small quantities, and frequently found floating as a scum of blue indigo on the surface of some pathological urines, as in peritonitis (Jaffé). It has its origin in indol (C_8H_7N), a body formed in the putrefaction of albumin in the intestinal canal, which body is oxidized in the organism into indoxyl, which in turn combines with sulphuric acid and appears in the urine.

Nitrogenous or Proteid Metabolism.—Deprive an animal entirely of food and the bodily functions still continue for a considerable length of time, and during the whole period of hunger and starvation, up even to the time of death, the ordinary decomposition and excretory products appear continuously in the urine. Thus in the case of a girl, nineteen years of age, deprived of food for sixteen days, owing to a closure of the œsophagus, Schultzen [59] found 6 grams of urea daily on the two last days of life, and Seegen [60] likewise obtained 8.9 grams of urea daily from the urine passed in twenty-four hours by a girl just dying of complete starvation. In a similar manner the fat of the body continues to be decomposed up to the time of death. Diminution in the daily amount of excretory products, however, during starvation, is not regular, but is, as a rule, rapid on the first two or three days, then remains fairly constant until toward the end, when there is a final rapid falling off in nitrogenous metabolism. While, then, nitrogenous metabolism continues during hunger, even up to the point of death, at the expense of the proteid matter of the tissues, it might be expected that a diet of lean meat given to a starving animal, whose body had become deficient in flesh, would be at once stored up and only a minimum amount thrown off as urea. Such, however, is not the case ; the larger amount at once passes off as urea, and only a small amount is retained and stored up in the tissues. Further, if the diet be a generous one, and be long continued, the proportion of nitrogen excreted as urea is continually increased, until finally a condition is reached in which the amount of nitrogen excreted exactly equals the nitrogen of the ingesta ; a condition of so-called *nitrogenous equilibrium*. Evidently, then, one of the effects of a purely proteid diet is to increase nitrogenous metabolism. Moreover, the daily decomposition of proteid matter increases proportionally with the increase in proteid diet. This is well shown in the following table of results obtained by Voit [61] with a dog :

Daily diet of flesh.	Daily amount of urea excreted.	Daily diet of flesh.	Daily amount of urea excreted.
Grams.	Grams.	Grams.	Grams.
176	27	1,240	88
300	32	1,500	106
480	35	1,800	128
500	40	1,900	139
600	49	2,000	144
800	56	2,200	154
900	68	2,500	173
1,000	77	2,660	181

The extent of proteid metabolism, however, is not dependent on the absolute amount of proteid matter ingested, but rather on the amount proportional to the body-weight ; thus, while ten grams of flesh, in the case of a small dog, would lead to an increase of body-weight, the same amount of food in the case of a large dog would be insufficient to prevent even the decomposition of a portion of its tissue-proteids.

In order to establish nitrogenous equilibrium large quantities of proteid food are necessary, the exact amount, of course, depending on the size of the animal, its condition, etc., particularly on the amount of proteid matter and fat contained in its tissues. Naturally there is a limit to the amount of proteid matter which an animal is capable of utilizing, depending on the absorptive power of the intestines for albumin. Thus Voit found that a dog weighing 35 kilos. in nitrogenous equilibrum, could decompose 2,500 grams of flesh, equal to 548 grams of dry albumin. Further, the dog was able to digest 2,600 grams of flesh, but in this case 126 grams were deposited in the tissues, while an attempt to digest 2,900 grams of the meat was followed by vomiting and diarrhœa with discharge of undigested flesh.

Further, nitrogenous equilibrium does not necessarily imply that the body-weight is constant. On the contrary, when the amount of proteid food necessary to balance the nitrogen is large, then the body may gain in weight, owing, as we shall see later on, to a deposition of fat.

This naturally implies that proteid food, in its decomposition in the alimentary canal, or elsewhere, is broken

down into two dissimilar parts, one of which is doubtless non-nitrogenous and the source of the deposited fat, while the other leaves the body at once in the form of urea. This, if true, would explain why it is that a meat diet so quickly increases the urea excreted.

In this connection it must be remembered that destructive proteid metabolism (katabolism) is mainly oxidative in character, and that contrary to the old idea, oxidative changes do not take place to any great extent in the blood, and consequently the metabolism of proteid matter, or at least the conversion of its nitrogenous residues into urea, or some antecedent substance, must occur in the tissues and through the agency of the tissue cells. In the tissues are to be recognized two forms of proteid matter; that which becomes an integral part of the living cells or framework of the tissue, the *morphotic* proteids, and that which, as Foster expresses it, is "found in the internal meshes of the unit or in the surrounding lymph, or in the blood, and which, since it probably passes readily from one medium to the other, may be spoken of as the *circulating proteids*." Hence, in considering proteid metabolism we must discriminate between morphological and physiological destruction and renewal. The tissues themselves, or rather their morphological framework, undergo but partial destruction and renewal, and that only to a variable extent. As Foster says, "a muscle may suffer very considerable wasting and recover from that wasting without any loss or renewal of its elementary fibres." The cells, however, in the performance of their functions, produce changes in the surrounding lymph, or in the material lying in the spaces of the morphological framework, without the matter thus changed ever becoming an essential part of the cells themselves. At the same time the true tissue- or morphotic-proteids, those composing the actual living framework of the body, may suffer metabolism. On this fact is founded the view of a twofold origin of the excreted urea, corresponding to the metabolism of these two forms of proteid matter. One part of the urea, particularly that which appears as the immediate result of food, would, presumably, come from the metabolism of the circulating proteids, while another smaller part would have its origin in the metabolism of the tissue-proteids. Foster, however, considers it quite possible that the marked increase in the excretion of urea which follows a meal rich in proteids, may be due simply to a destructive digestion of the latter while in the alimentary canal. However that may be, we have to consider at present that the main bulk of the excreted urea comes from the destructive metabolism of the circulating proteids.

Proteid food, as already stated, will keep the content of albumin in the body of a carnivorous animal quite constant. In addition, Pettenkofer and Voit have shown by experiments on dogs that a sufficient amount of proteid food will also prevent the loss of any of the body fat. Increasing, however, the amount of proteid food to such an extent that nitrogenous equilibrium is established, then the amount of carbonic acid excreted is less than the equivalent of the carbon in the decomposed proteid matter; in other words, a portion of the carbon of the proteid food is retained and deposited in the form of fat. On a pure flesh diet, however, the amount of carbon so retained is never large. If the body is rich in fat from previous good feeding, then an abundant proteid diet will lead to a loss of fat, whereas a hungry animal, or one poor in fat, will, under such a diet, acquire fat from the decomposed albumin.

Peptones, or rather albumoses, and similar products formed in the digestion of albuminous matter, apparently do not lead to the formation of albumin, but are presumably directly decomposed, saving, however, by their decomposition the albuminous matter in the tissues and cells, and thus for the time being preventing any withdrawal of albumin from the body other than in the form of cast-off tissue or cells, as epidermal, etc.

Gelatin, or collagenous food, although nitrogenous, is not capable of supplying the place of albuminous food. The nitrogen of the gelatin is completely excreted, but even after large doses of gelatigenous food the excreta contain more nitrogen than the gelatin fed; the reason apparently being that gelatin is more easily decomposable than albumin, and further, that it is not able to take the place of albumin in supplying the needs of the body. Gelatin, like fat and carbohydrates, diminishes the metabolism of proteid matter, saving thereby a certain amount of albumin for the body. Addition of fat to gelatin diminishes still more the extent of proteid metabolism. With gelatin alone, however, a certain amount of albumin is continually decomposed, and hence, on a purely gelatin diet, or on a mixture of gelatin with fat and carbohydrates, an animal would ultimately die in much the same manner as on a purely non-nitrogenous diet. It is probably true, as Foster suggests, "that gelatin is rapidly split up into a urea and a fat moiety," and thus "it is able to take up the direct destructive metabolism of proteid matter, but is wholly unable to imitate the other function of proteid matter, and to take part in the formation of living protoplasm."

Influence of Fats and Carbohydrates on Metabolism.—Obviously the effects of fats and carbohydrates on the metabolism of the body cannot be studied alone, since deprivation of proteid food would soon result in death. We have, then, to consider mainly the influence of these two forms of foods on proteid metabolism. With an exclusively proteid diet the decomposition of albumin, in a body rich in fat, is less than in a body whose tissue is poor in fat, and hence it naturally follows that the addition of fat to a proteid diet would tend to diminish proteid metabolism. As has already been stated, a gradually increasing amount of proteid food leads to a proportional increase in proteid metabolism, and under such conditions the addition of a little fat does not change the amount of albumin decomposed, showing, as Voit suggests, that the decomposition of proteid matter is, mainly at least, quite independent of the fat added. Fat, however, as may be easily demonstrated, tends to lower the consumption of proteid matter, and the addition of fat or carbohydrate to a proteid diet tends to decrease the proteid metabolism necessary to establish nitrogenous equilibrium. With a fixed fat or carbohydrate diet, increase of the accompanying proteid food tends to augment the consumption of carbon by the body. At first glance it might naturally be supposed that the increased carbon contained in the proteid food would be stored up, but experiments show that such is not the case; in fact, increase of proteid food increases not only proteid metabolism, but also that of non-nitrogenous matter, which shows how it is possible for excess of proteid food to actually diminish the fat of the body. Fats and carbohydrates, on the other hand, do not so noticeably increase the metabolism of the body; thus, when a small amount of fat or carbohydrate is added to a fixed proteid diet of average amount, none of the carbon, to be sure, will be laid up; but as the fat or carbohydrate is increased in amount, then the carbon of the non-nitrogenous food will begin to be retained, either in the form of fat, glycogen, or allied substance. Obviously, then, if it is desired to have the body store up albumin together with fat, proteid matter must be given only in moderate amount, and in proportion to the albumin a large amount of fat should be added. The fat of the food is, of course, decomposed in considerable quantity,[62] and in somewhat larger amount with a small or moderate addition of proteid food than in a condition of hunger; due, of course, to the stimulating influence of the increased proteid metabolism. On the other hand, experiments show that with a large amount of proteid food, the carbon retained by the body is nearly equal to that contained in the fat of the food; from which it might be argued that the fat of the food is directly stored up, while the carbon of the decomposed albumin is excreted. Voit considers that albumin, or rather that portion rich in carbon which results from the decomposition of the albumin molecule, must be more easily decomposable (into carbonic acid and water) than the fat of the food. Further, the larger the amount of albumin decomposed, the less will the fat of the food be attacked, and accordingly, the smaller the amount of albumin, the larger the amount of fat decomposed.

Young and growing animals need more albumin in their food than older ones, because their bodies are poorer in fat, and for a similar reason during hunger they decompose more albumin. Small organisms use up, proportionally during hunger, large amounts of albumin, while the decomposition of fat is increased only slightly (Voit).

Carbohydrates, or at least those which have been tested, affect proteid metabolism in much the same manner as fat, and Voit has shown that like quantities of the more important ones are exactly similar in their action. Like fat, they all tend to diminish somewhat the metabolism of proteid matter, but experiments (Voit) tend to show that while increased doses of fat, the proteid diet remaining constant in amount, do not invariably act as a check on proteid metabolism, every increase of carbohydrate matter brings about a regular diminution in proteid decomposition; in other words, carbohydrates favor the laying on of albumin more than fats do. Thus carbohydrates play an important part in aiding the body to keep up its content of proteid matter.

Carbohydrates, further, have an important influence on the decomposition of fat within the body, diminishing to a very marked degree its metabolism, thus preventing a loss of fat, and, in addition, leading to a storing up of carbon, presumably in the form of fat. Carbohydrates, too, are very readily decomposable, much more so than fat, and by absorption of oxygen they are rapidly oxidized, ultimately to carbonic acid and water. Increase of carbohydrate diet leads to an increased excretion of carbonic acid, and it has been suggested that this increase of carbonic acid is due to increased decomposition of the body fat, the carbohydrate itself being changed into fat, and then stored up. As Voit suggests, however, it is much easier to suppose that the carbohydrate of the food decomposes more readily into simple products than fat, and that the latter is burned up only when the carbohydrate of the food is insufficient for the needs of the body. Addition of fat to a diet rich in proteids does not lead to an increased excretion of carbonic acid; in other words, the fat is not oxidized. It is further probable that the carbohydrate matter absorbed from the intestines is more readily oxidized than the non-nitrogenous moiety, rich in carbon, split off from the albumin molecule.

On a medium diet of flesh and carbohydrate the carbon excreted corresponds nearly with the amount ingested (experiment on dogs by Voit and Pettenkofer). With somewhat larger amounts of proteid matter and smaller amounts of carbohydrate, less carbon is found in the excreta than in the ingesta, so that some carbon under these circumstances must be retained by the body and derived either from the carbohydrate or from the decomposed albumin after separation of the nitrogenous products. With still larger amounts of proteid food, together with considerable carbohydrate, the retention of carbon is very much greater, and as it is hardly probable that the retained carbon is stored up in the form of glycogen, sugar, or lactic acid, we must assume that the absorbed carbon exists in the form of fat (Voit). The all-important question, however, is, whether this fat has its origin in the decomposition of the proteid matter or in the decomposition of the carbohydrate material. It is obvious that a portion of the fat may originate from the albumin, or at least at the expense of the albumin, since a laying up of carbon may take place on a purely proteid diet. Henneberg[63] assumes that, in extreme cases, albumin by decomposition might yield an amount of carbon corresponding to 51.4 per cent. of fat, and Voit finds by experiments with carnivorous animals that on a pure carbohydrate diet, where there is a storing up of fat, the amount of fat so deposited corresponds closely with Henneberg's assumption; taking, of course, the nitrogen excreted as the measure of the amount of body albumin decomposed. Again, numerous experiments testify to the fact that the extent of proteid metabolism is of more direct influence on the storing up of fat than the carbohydrate, and further, the absolute amount of fat laid up by the body bears a far closer relation to the amount of albumin decomposed than to the carbohydrates. This is well shown in the following table:[64]

	Meat Grams	Carbohydrate	Fat (+) or (−) Grams
1	271	358	+ 24
2	1,0[illegible]	6[illegible]	− 22
3	450	211	− 8
5	413	511	+ 39
6	500	107	+ 20
9	608	379	+ 55
10	1,455	152	− 43
11	1,809	608	+ 112

Thus, in Nos. 1, 5, 9, and 11 the deposition of fat is proportional to the consumption of proteid matter. Further, Voit found that by feeding 1,800 grams of meat together with 379 grams of starch, the storage of fat was five times greater than by feeding the same quantity of starch without any meat; a fact which it is difficult to comprehend on the assumption that the body fat has its origin in carbohydrate matter alone.

Carbohydrates certainly exercise a very great influence on the storing up of fat, since large quantities lead to a noticeable increase, as in No. 11, where the gain in fat over No. 10 is quite large, though the amount of proteid food-stuff was practically the same in both cases. This, however, happens only when sufficient albumin is decomposed, and not when the animal is deprived, wholly or in part, of proteid food, as in No. 2, where the carbohydrate food is the same in amount as in No. 11; a fact which, as Voit argues, plainly shows that carbohydrate is certainly not the only material from which fat is formed. If, however, fat has its origin in a portion of the albumin molecule split off during digestion, or later on, then this antecedent substance would behave in much the same manner as the fat of the food; and hence, as Voit points out, it would be protected by the more easily decomposable sugar, and thus be saved for storage as fat. This view being correct, it is quite clear how carbohydrate food is necessary to save all of the fat capable of being formed from a given amount of albumin; the carbohydrate matter itself, in the case of carnivorous animals, being oxidized completely to carbonic acid and water. On an exclusively carbohydrate diet less albumin is decomposed than during hunger, while the loss of fat gradually becomes less and less, until finally there is no loss whatever.

With especial reference to the formation of fat in the animal body, it is obvious from the foregoing that while the albumin of the body is formed only from the albumin of the food, fat has its origin not only in the fat absorbed from the food, but also in the decomposition of other chemical compounds, or else by some kind of synthetical construction. Experiments tend to show that the fat of the food may be absorbed as such, and be stored up in the organs and tissues. Thus Hofmann[65] experimenting with a small dog which had been deprived of food for some days, and its tissues thus freed from fat, found that on feeding a large amount of fat with only a little albumin, there was absorbed from the intestines during five days 1,854 grams of fat, of which 1,353 grams were retained by the body, the liver containing 66 grams, or nearly forty per cent. by weight. Feeding experiments, however, with foreign fats, as spermaceti, tried mainly by Radziejewski[66] and Subbotin[67] show that there is no storing up of these fats, while the fat of the body contains the usual normal constituents in spite of their absence in the food, and thus this fact has been used as an argument that all the fat found in the cells of the body must have its origin in some process of decomposition of a non-fatty substance, such as albumin or sugar. It is just as plausible, however, to suppose that such foreign fats are more readily decomposed than the characteristic animal fats, or that in this case, as in Hofmann's experiments, there may have been a reconstruction of fat out of the carbon of the fat absorbed.

It is evident, however, that a construction of fat does occur in the body somewhere, since only a small part of

the fat ordinarily stored up by the body can come from the fat of the food.

As to the possibility of fat being formed directly from carbohydrates, there are many suggestive reactions other than the well-known influence of carbohydrate matter on the storage of fat, already explained, which lend favor to this view. Thus in the higher plants it is stated that a transformation of starch into fat takes place,[68] also among the lower plants (De Bary); while Hoppe-Seyler [69] has plainly shown the formation of fatty acids, such as butyric, caproic, etc., from carbohydrates, and that, without the intervention of bacteria. Further, the well-known formation of fat by herbivorous animals, the diet of which is mainly carbohydrate matter, might be taken as evidence of such origin; the noticeable formation of butter-fat by the cow, the remarkable fattening of swine and geese, are often quoted as examples of the formation of fat from carbohydrate diet. While these and many other facts lend favor to this view, and suggest the possibility of such a decomposition, absolute proof of the fact is wanting. Unquestionably a carbohydrate diet is especially adapted to produce an accumulation of fat in the body, but whether this accumulation is due to direct conversion of the starch or sugar into fat, or whether it produces this effect by sheltering the carbon moiety of the metabolized albumin, and from which the fat may be formed, is difficult to decide. Quite probably both views are correct, and fat may have a double origin: carbohydrates, on the one hand, and the carbon-holding portion of proteids on the other. In support of the view that the body-fat has its origin in proteid matter, is the fact, often quoted, that protoplasm, both during life and after death, is subject to fatty degeneration, in which fat is certainly formed from the breaking down of proteid compounds. Further, in pancreatic digestion albuminous matter is regularly decomposed by the proteolytic ferment into leucin and tyrosin, the former of which bodies is amidoisocaproic acid, a fatty acid belonging to the same series as butyric and palmitic acids.

In direct connection with the formation of fat in the animal body we have the formation of glycogen in the hepatic cells. This, in the words of Foster, constitutes the best known and most carefully studied example of metabolic activity. Ever since Claude Bernard made the discovery that the liver is a source of sugar, the glycogenic function of the liver has been most carefully studied. As to the exact source of the liver glycogen, however, there is still lacking a perfect unanimity of opinion. The amount of glycogen present in the liver at any one time is mainly dependent upon the nature and amount of the food taken. When an animal, as a rabbit, is entirely deprived of food, the glycogen in the liver commences to diminish quite rapidly, and at the end of seven or ten days is almost entirely, or quite, absent. By feeding such an animal on carbohydrate matter of any kind, glycogen at once commences to accumulate in the liver in large quantity, and thus the opinion has long been prevalent that carbohydrate food converted into soluble dextrins and sugar by the amylolytic ferments of the body, and then carried to the liver by the portal circulation, is quickly converted into glycogen by the metabolic activity of the hepatic cells. Glycerin, too, when introduced into the intestines, also increases the amount of liver glycogen; but here it is very evident that the hepatic cells alone are not able to induce the change, since the subcutaneous injection of glycerin leads to no production of glycogen. Evidently some action of the digestive juices is necessary to prepare the glycerin for its further change. The great difficulty in accepting the simple view that carbohydrate matter is the sole source of the liver glycogen, lies in the fact that not only glycerin, but also a pure proteid diet fed to a hungry dog, whose liver is quite free from glycogen, also leads to an accumulation of this substance in the liver, although to a less extent than carbohydrate matter. Gelatin also leads to the formation of glycogen, while fat is entirely without action.

Whatever the origin of the liver glycogen, we have next to consider its destination. Stored up for a time in the liver, it gradually disappears unless appropriate food is taken to keep up the supply. Now it so happens that those foods which are especially fattening lead also to the most rapid accumulation of glycogen, and further, glycogen and fat accumulate in the hepatic cells to about the same extent; whatever leads to an accumulation of glycogen also leads to an accumulation of fat in the liver. Hence it is quite natural that the view should have been advanced that the formation of glycogen is simply a phase in fatty anabolism; that glycogen is an antecedent of fat. For this view, however, there is very little positive evidence. Perhaps the strongest ground for belief in it is the fact that it is somewhat questionable whether the blood of the hepatic vein contains any more sugar than the other blood of the body. If it does not, then the natural inference is that the hepatic glycogen, not being changed into sugar, must be converted into fat. In further support of this view we have the recent statements of Seegen, and of Seegen and Kratschmer, that the sugar formed in the liver, contrary to the usually accepted opinion, does not originate wholly, at least, in the liver glycogen, but is formed from some other material, particularly peptones. This, however, has been contested,[70] and it is more than probable that the ultimate fate of the liver glycogen is to be converted into sugar, to keep up the average composition of the circulating blood; in which case the hepatic glycogen is to be considered simply as a reserve fund of carbohydrate material, to be drawn upon as the needs of the body may demand.

Influence of Various Therapeutic and other Agents on Metabolism.—Large quantities of water apparently tend to increase nitrogenous metabolism, as shown by the increased excretion of urea noticed in both carnivorous and herbivorous animals on giving large volumes of water, while in a state of nitrogenous equilibrium. The increased excretion of nitrogen, however, has sometimes been explained on the supposition that the increased amount of fluid flowing through the kidneys serves to wash out more completely the formed urea, and that in reality there is no actual increase in proteid metabolism.

All salts, like sodium chloride, which tend to increase the flow of urine, either by causing thirst and thus leading to the drinking of more water, or by their action as diuretics, tend to increase the excretion of nitrogen, and presumably, therefore, act as stimulants to proteid metabolism. Certain salts, however, possessed of such qualities may, in addition, owing to other physiological properties, produce an effect in the opposite direction more than sufficient to counterbalance the former. Ammonium carbonate [71] causes an increase in proteid metabolism, as does also borax,[72] sodium phosphate,[73] and presumably, also, sodium sulphate when taken in large doses.[74] The bromides of potassium and ammonium [75] also increase nitrogenous metabolism. Of the salts of the heavy metals iron has apparently but little if any action on metabolism,[76] as would also seem to be the case with mercury.[77] Small medicinal, or non-toxic doses of arsenious acid,[78] have no effect on proteid metabolism; larger toxic doses, however, cause an increased excretion of nitrogen.[79] With antimony Gähtgens [80] claims to have found evidence of increased proteid metabolism on feeding a hungry dog with tartar emetic. The writer,[81] experimenting with antimonious oxide, and carrying the doses up to the point of toxic action, could find no indications of influence on the excretion of nitrogen, of sulphur, or of phosphorus.

Of the alkaloids, quinine [82] diminishes very materially proteid metabolism, and for some reason appears to exert a special influence on the excretion of uric acid, diminishing its amount in some cases even seventy-two per cent.[83] In small doses quinine diminishes the excretion of carbonic acid, but with larger doses, where there is vigorous muscular contraction and increased consumption of non-nitrogenous matter, there is a corresponding increase in the amount of gas given off. Cinchonidine [84] also lowers the rate of proteid metabolism, but apparently to a less extent than quinine. Morphine has mainly only an indirect influence upon metabolism, and that is espe-

cially exerted upon the decomposition of non-nitrogenous matter—increasing in the first stages of its action the elimination of carbonic acid and the consumption of oxygen due, as Boeck and Bauer[88] assert, simply to the increased muscular activity induced by the alkaloid. In the second stage of its action there is a diminished excretion of carbonic acid, the same as that induced by sleep.[89]

Antipyrine causes in man, according to Umbach,[87] a diminution in the amount of nitrogen excreted, which is more apparent in the elimination of urea than in uric acid. With digitalin Boeck and Bauer[88] have found, by experiments on dogs, that doses which tend to increase blood-pressure and the action of the heart, increase, as might naturally be expected, the elimination of carbonic acid and the consumption of oxygen; while doses of the poison which lead to a diminished heart-action reduce very decidedly gas metabolism. Alcohol, Munk[90] has found by experiments on dogs, in moderate doses, tends to diminish quite noticeably the decomposition of proteid matter, while larger doses evidently increase proteid metabolism. In a similar manner small doses diminish the elimination of carbonic acid, while large doses increase both the elimination of carbonic acid and the consumption of oxygen (Boeck and Bauer); this increase being due, without doubt, to increased proteid metabolism, but especially to the larger decomposition of fatty matter. Caffein,[90] theine, and other related bodies apparently have but little influence on nitrogenous metabolism. Large numbers of experiments have been tried with coffee, tea, and cocoa infusions, but the results have been exceedingly variable; doubtless due to lack of proper precautions in the arrangement of diet and other conditions.[91]

Other Modifying Influences.—The temperature of the surrounding air also has a decided influence upon the metabolism of the body. With cold-blooded animals the excretion of carbonic acid is proportional to the body temperature (1° to 34° C.), increasing as the temperature is raised.[92] It is questionable, however, how far the increased excretion of gas is due to the direct influence of the warmth, and how much to the greater muscular activity usually attendant upon rise in temperature. With warm-blooded animals, experiments plainly show that so long as the animals retain their normal body temperature exposure to cold tends to increase the elimination of carbonic acid, while exposure to a higher temperature diminishes the consumption of oxygen and the excretion of carbonic acid. If, however, the body temperature in a curarized animal is lowered or raised by a change in the surrounding medium, then the effect produced is the same as with cold-blooded animals. Evidently, then, in the warm-blooded animal there is a mechanism of some kind (the action of which is hindered or destroyed by curare) which counteracts the direct effects of change in temperature. Pflüger's[93] experiments on rabbits show plainly that ordinarily, while the heat-regulative mechanism is in working order, exposure to cold acts as a stimulant, leading to more energetic metabolism, while exposure to a higher temperature diminishes metabolic activity. Further, there is a close connection between lowering of temperature and muscle-contraction, as is well shown by the low temperature of hibernating animals during their winter's sleep and their elimination of carbonic acid; and since muscles make up so large a part of the body and must necessarily by their metabolic activity furnish a large portion of the heat of the body, it is fair to presume that they are connected in some way with the skin through their motor nerves and the central nervous system, so that any change of temperature affecting the skin would, through the agency of some thermotaxic reflex mechanism, lead to an increase or decrease of muscle metabolism.

On proteid metabolism of warm-blooded animals exposure to cold has no noticeable effect, provided the heat-regulating mechanism of the body is unimpaired. By lowering the normal body temperature, however, there is a decided diminution in the decomposition both of proteid matter and of fat. Raising the body-temperature (the thermogenic nervous mechanism being interrupted) brings about an increase in proteid metabolism. When, however, a warm-blooded animal in normal condition is exposed to excessive cold, the reaction of the thermotaxic nervous system is powerless against the depressing direct effects, and the metabolism, together with the temperature, sinks (Foster).

Muscular exercise exerts a very decided influence upon body metabolism. Contrary, however, to the older views of Liebig, it is evident that muscle tissue is not fed exclusively on proteid matter, nor does muscular energy come exclusively from the metabolism of the proteid constituents of muscle. Severe muscular exercise does not exert any great influence on nitrogenous metabolism. On the contrary, the production of carbonic acid is greatly increased by muscular exercise, and thus it is plain that during muscular contraction a decomposition takes place, the non-nitrogenous products of which leave the muscle and are eliminated from the body, while any nitrogenous products formed are retained within the muscle tissue. By poisoning with curare, where there is a complete cessation of voluntary movements, a noticeable diminution in the excretion of carbonic acid is to be observed, but no apparent change in the elimination of nitrogenous excreta. Further, during the rest attendant upon sleep the absorption of oxygen and the elimination of carbonic acid is diminished, while the excretion of nitrogen is unchanged except so far as it is influenced by the food. The effect produced by sleep, however, is not due wholly to cessation of voluntary motion, but in part also to stopping of the processes or changes in the nerves and central nerve organs incident to lack of excitation of the various sensory organs.

It is evident, moreover, from what has already been pointed out, that the nervous system has the power of directly affecting the metabolic activity of the body, as is well illustrated in the influence, for example, of division of all the nerves of a salivary gland on its secretion; the secretion continues, but its character is profoundly altered; the cells lose their metabolic power, and ultimately even the tissue of the gland degenerates, owing to the lack of its customary nervous guidance.

Theories as to the Cause of the Decomposition of Matter in the Body.—At one time oxygen was supposed to be the prime cause of the decomposition of matter in the body, and the various processes of decomposition were compared to processes of combustion or oxidation. Pflüger,[94] however, pointed out that the decompositions of matter incident to life are not in every case due to direct oxidation, but in many cases are due to dissociation, as in the decomposition of proteid matter; and further, it was shown that the amount of oxygen inspired has no influence on the production of carbonic acid. Certainly the nutritional changes which take place in the animal body cannot be explained by simple oxidation, in which oxygen unites directly with the elements of the food. The changes are more complicated, and we find in many cases a cleavage of some chemically complex substance, totally independent of oxygen, by which two or more simpler substances result, and that apparently without the addition of anything whatever; a process which we may call dissociation. Again, by the taking on of a molecule or more of water, a hydrolytic cleavage may occur, and lastly, by the absorption of oxygen, an oxidative cleavage. Toward the end of the nutritional changes oxidation and reduction processes are more common, and many of the products of katabolic action are removed from the body in an oxidized condition. Thus, while oxygen plays a very important and absolutely essential part in respiration and in the nutritional changes of the body, it is not to be considered as the prime cause of metabolic action.

The widespread distribution of unformed ferments in the animal organism has naturally led to the view that these bodies are the cause of metabolic activity. They certainly play an important part in the decomposition of the various food-stuffs, and they are found not only in the alimentary canal, but also in small quantity in the various organs and tissues of the body. They unquestionably exert great influence on nutrition, but as yet fer-

ment action is insufficient to explain the more important metabolic changes occurring in the organism. The action of the unformed ferments is exerted only upon the non-organized matter of the body. The organized matter of the organism, that which makes up the structure of the cells and cell tissue, like the former, undergoes change, and it is in the cells themselves that the most important metabolic phenomena occur, but not through the agency of unformed ferments. The various fluids of the body, the plasma of the blood, the lymph, etc., are carriers of nutritive matter to the decomposing elements of the tissue, and also carriers of the decomposition products from the tissue elements to the excretory organs. It is in the cells, however, that metabolic action manifests itself, but the cause of that action cannot be explained. It is something inherent in the cell itself, something on which the life of the organism depends, and, so far as we can see, is of the same nature in the single unicellular organism as in the larger multicellular animal.

Pflüger[95] has attempted to explain the whole process of metabolism on the supposition of a partial decomposition and regeneration of the living albumin molecule—the view being that only living albumin is decomposed in the animal body. This hypothesis further supposes that living albumin is exceedingly prone to change, while dead food albumin is much more resistant. Now, it is a well-known fact that the decomposition products of dead albumin, obtainable by chemical means, are quite different in nature from those formed by proteid metabolism in the living organism. The former are amides or amido-acids, containing radicals belonging to the fatty acid or aromatic series of compounds, while the latter decomposition products, like urea and uric acid, contain, instead of the amide group (NH_2), the cyanogen group (CN), and in this connection it is well to remember that the latter products have never been obtained by the decomposition of dead proteid matter outside of the body. Thus Pflüger's hypothesis assumes the conversion of food albumin into living albumin by a change of the amide group into the cyanogen group, which change implies the expenditure of a certain amount of force, since the intramolecular motion in the cyanogen group is much greater than in the amide group. On this latter point, according to Pflüger, depends the easier decomposition of living albumin.

More recently, Loew and Bokorny have advanced a somewhat fanciful hypothesis, that the difference between living and dead albumin is to be found in the presence of aldehyde groups in the former; the presence of which, by their great energy, cause "intense motion in the albumin molecule," which, according to Loew's opinion, is "the cause of life."[96] The hypothesis is based mainly on the fact that the living protoplasm of certain needle-like algæ shows a noticeable reducing action on a dilute ammoniacal silver solution. In dead cells no such reducing action can be obtained. Not very much weight is to be attached to this theory.

R. H. Chittenden.

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NUX VOMICA (U. S. Ph., Br. Ph.; *Semen Strychnin*, Ph. G.; *Noix vomique*, Codex Med.; Poison Nut, "Quaker Buttons," etc.). The seed of *Strychnos Nux-vomica* Linn.; Order, *Loganiaceæ*. This is a medium-sized tree, with a short, thick, dark-gray trunk, and irregularly spreading, crooked branches; branchlets yellowish-gray, nearly smooth, di- or tri-chotomously branching, ragged-looking on account of the persisting bases of the leaves, and sometimes terminating in a sort of spine. Leaves opposite, thick, short-petioled, broadly oval, blunt-pointed at the base and apex, entire three- or four-nerved, bright green and shining above, paler below, both sides smooth. Flowers perfect, in small, terminal panicles, regular, pentamerous; calyx short, five-toothed, pubescent on the outside; corolla funnel- or salver-shaped, about a centimetre long, greenish-white, five-lobed, hairy within; anthers five, inserted at the throat of the corolla, nearly sessile. Ovary small, superior, two-celled, many-ovuled; style single, long and slender; stigma capitate, obscurely two-lobed. Fruit a large, round, solid, yellow berry,

looking at a distance like a small orange, and consisting of a tough, hard rind, a greenish white, solid, bitter pulp, and a few—four or five or more—large, flat, coin-shaped seeds. The traces of the early partitions are nearly obliterated. The seeds themselves will be described below. All parts of the nux vomica tree are bitter and poisonous.

This interesting plant is a native of Southern India and of the principal islands of the Australian and Indian groups. It also grows in Burmah, Cochin China, and other parts of tropical Asia. The drug is imported in large and increasing quantities from British India. Nux vomica, strange to say, is not among the ancient medicines, even in its native countries. Its first introduction into Europe was only some four or five hundred years ago, and its early employment was as a poison for domestic and farm vermin, dogs, cats, rats, and troublesome birds.

Fig. 2522. — Flowering Branch of Strychnos Nux-vomica. (Baillon.)

Description. — The seed is round and flat, from two to three centimetres in diameter, and about half a centimetre in thickness; concave on one side, flat or slightly convex on the other, so as to be like a blood-corpuscle; thinner in the middle than near the margin; sometimes moderately bent or folded; very hard and tough. On the convex surface, at its centre, is the chalaza or scar, where it was attached to the placenta. From this a narrow raised line runs directly to a little protuberance at the edge of the seed where it terminates; this line is the raphé, the protuberance, the hilum, where the end of the radicle rests. The substance of the seed is of a translucent gray or bluish gray color, but it is covered with a thick layer of closely appressed, stiff, glistening hairs, radiating from the centre of the sides to the margin, where, meeting with those of the opposite side, they form a sharp but narrow edge. The hard and horn-like albumen, of which the seeds mostly consist, is split, by

Fig. 2523. — Fruit of Nux-vomica Tree cut transversely, showing the Seeds much more numerous and more regularly arranged than usual. (Baillon.)

an extensive fissure parallel with the sides, nearly into halves; in this chink near the hilum lies the embryo, about a centimetre long, having a short, thick radicle, and two heart-shaped foliaceous cotyledons. The albumen consists of thick-walled parenchymatous cells—the hairs of stout, long longitudinally striate ones.

Composition. The bitterness, poisonous character, and medical value of Nux Vomica depend on the presence of two alkaloids—*strychnine* and *brucine*—which exist in the seeds in combination with a peculiar acid base called *igasuric* acid, probably a sort of tannin.

Beside these it contains a considerable amount of *albuminoids*, some *fat*, *resin*, and other common vegetable substances, but no starch. The most important of these substances, *strychnine* (*Strychnina* U. S. Ph.), was first discovered by Pelletier and Caventou in 1818, in the seeds of the nearly related *S. Ignatia*, and is, therefore, one of the earliest known alkaloids. It was soon afterward obtained by them from the seeds under notice, and has since been found in the wood, bark, and fruit of the nux-vomica-plant, as well as in a few other species of the genus (*S. colubrina* Linn.; *S. Tieuté* Lesch.); but it is not found beyond the generic limits. It is a permanent crystalline solid, of decidedly basic properties, forming, with many acids, crystalline salts. It has a most intensely bitter taste, although very insoluble in water.* It melts without change, but sublimes with difficulty. The Pharmacopœia description is as follows: "Colorless, octahedral, or prismatic crystals, or a white crystalline powder, permanent in the air, odorless, but having an intensely bitter taste, which is still perceptible in highly dilute (1 in 700,000) solution, and of an alkaline reaction. Soluble in 6,700 parts of water and 110 parts of alcohol at 15° C. (59° F.); in 2,500 parts of boiling water, and in 12 parts of boiling alcohol; also soluble in 6 parts of chloroform; but almost insoluble in ether or in absolute alcohol. . . . On adding to a few drops of cold, concentrated, sulphuric acid, one drop of a solution of strychnine, or of any of its salts, and then a small crystal of bichromate of potassium, a deep blue color makes its appearance, rapidly passing into violet, then cherry-red, and fades after some time." If the strychnine contains much brucine it will be reddened by nitric acid. A number of strychnine salts are in commerce, but the sulphate is in by far the most demand in this country, and is understood when "strychnine" is spoken of as a medicine. This salt, *Strychninæ sulphas*, U. S. Ph., is in large, white, shining, prismatic crystals, efflorescent in dry air, odorless, but having an intensely bitter taste and a neutral reaction. It

Fig. 2524. Seed of same, and Longitudinal Section of Seed, showing the Embryo. (Baillon.)

* It is said to give a distinct taste to six hundred thousand parts of water.

is soluble in ten parts of water and in sixty of alcohol, much more so in boiling alcohol. There are numerous methods of separating strychnine from nux vomica, all more or less similar; that of the previous U. S. Pharmacopœia consisted essentially in exhausting it by boiling in successive quantities of considerably diluted hydrochloric acid, which formed a hydrochlorate with the strychnine, then evaporating these solutions to small compass and decomposing and precipitating the two alkaloid salts (strychnine and brucine) by means of lime, separating and washing the precipitate, dissolving out the brucine by means of diluted alcohol and then boiling the residue repeatedly in alcohol, which removes the strychnine. This is recovered by evaporating the alcohol, purified by redissolving in acidulated water, filtered, evaporated, and precipitated with ammonia.

Brucine, the companion alkaloid of strychnine resembles it in bitterness and poisonous character, but is in every way milder and is much more soluble. It was discovered by the same chemists, in 1819. Brucine is soluble in about eight hundred parts of water at the ordinary temperature and in a hundred and fifty parts of boiling water. In alcohol it dissolves to almost any extent (one and a half part). Its reaction with strong nitric acid is highly characteristic; with this it gives a blood-red color, fading out through orange and yellow.

The proportion of these alkaloids in Nux Vomica varies considerably, but from one-fourth to one-half of one per cent. of the first, and from one-tenth to one per cent. of the latter are given by Flückiger in the Pharmacographia. This amount is often exceeded.

Action and Use.—The action of Nux Vomica is essentially that of its contained strychnine, the brucine being overshadowed by it as the lesser cinchona alkaloids are by quinine. Strychnine, then, is one of the most intense and energetic of poisons, acting deleteriously upon nearly all forms of animal and vegetable life. There are, however, considerable differences in the susceptibility of different creatures to its influence, and in general those which are destitute of or have but a primitive nervous system, withstand it better than the higher organisms. Thus, as an antiseptic or anti-ferment, it is less efficient than quinine and other things far less poisonous to man. Many of the animals included under the term infusoria withstand it well; mollusks, leeches, and cockroaches are not very susceptible to it. Hens, some other birds, and guinea-pigs require larger doses than most animals of their size; and, finally, at least one bird and one insect can use as daily food a considerable amount of it, for a certain kind of crow is said to eat the bitter pulp of the Nux-Vomica fruit, and the seeds of Ignatia, containing as much or more strychnine than Nux Vomica, are not infrequently worm-eaten. All these instances, however, but little affect the truth of the general statement that, at least for the higher animals, Strychnine is a violent and frightful poison. It is received readily through the usual channels of absorption—the stomach or intestine, rectum, subcutaneous tissues, or serous surfaces, and it acts with great rapidity. It is eliminated, like most alkaloids, by the kidneys, but rather slowly, and on this account may be slightly cumulative. Tolerance, by continued use, is not much increased. The general action of a person or animal suffering from strychnine-poisoning has been often, and not inaptly, compared to that of a patient having tetanus, excepting that the course of the former is condensed into as few, or fewer, hours than the latter has days. The masseter muscle is less early affected by strychnia than by tetanus. The general symptoms are as follows: If taken, as is usual, by the stomach in a sufficient dose to prove fatal, its effects are felt in from five to thirty or more minutes after being swallowed. A period of restlessness, of a suffocative sensation, or of trembling may be first noticed, but is as often absent, and the first symptom is then the characteristic convulsion. This is a sudden clonic attack upon all the voluntary muscles: the face is twitched, the limbs jerked and extended, the abdomen stiffened, the thorax held, and respiration impaired, and, finally, the attack becoming more tonic, ends in violent opisthotonos. After lasting a minute or so it passes off, and the patient lies relaxed and weak, sweating profusely, without pain, and with a clear but anxious mind. There is not the coma of epileptiform or uræmic attacks; consciousness and the special senses are not impaired. The intermission lasts but a few minutes, when the convulsion is renewed with greater severity, lasts perhaps longer, and leaves the sufferer more exhausted and distressed. So the attacks go on increasing in violence and frequency until they may be almost constant, and the patient dies in one of the convulsions, or he may pass away by simple exhaustion between them. Occasionally death occurs in the second or third convulsion; it has done so in the first, but usually half a dozen or so occur before the end. Death comes with great rapidity, sometimes in less than half an hour from the receipt of the poison; perhaps an hour is not far from the average. If, on the other hand, the patient is to recover, the convulsions quickly become less severe and frequent, and in two or three hours have disappeared entirely, leaving prostration and muscular soreness behind. Reflex action during strychnine-poisoning is exaggerated enormously—a touch of the body, jarring the bed, a breath of air, noise, or anything which may take the attention of the sufferer, being responded to by a convulsion—in fact, most of those occurring in the course of its action are produced in this way. It has even been doubted whether the spinal cord could originate an attack.

The physiology of the strychnine convulsion has been carefully studied, and its nature is pretty well settled. That it is of spinal origin was long ago proved by Magendie, and has been many times confirmed since by the following facts among others: 1, It does not take place unless the poison is allowed to reach the spinal cord, either by absorption or by direct application; 2, destruction of this centre suppresses it; 3, it takes place after the cord has been separated from the brain. Strychnine has been shown also not to affect in any marked degree the afferent or efferent nerves or the muscles; most of the ganglionic centres, however, are more or less stimulated by it. The vaso-motor centres are also stimulated by it, and contraction of the smaller blood-vessels, with increased blood-pressure, follows. The heart beats with great rapidity during the convulsions.

Small or medicinal doses produce a condition of quick responsiveness, amounting sometimes to nervousness and trembling and sudden starts. The special senses appear to be quickened by it, peristalsis of the bowels is stimulated slightly, and nutrition in general is improved. It is generally prescribed with these effects in view: First, as a tonic, it is in very frequent employment; by its bitter taste it may stimulate the stomach to greater digestive power, as other bitters, say gentian, do; but in this particular respect it is doubtful if it equals that simple bitter. Its stimulating action upon the active centres of motion and nutrition, however, come here into play, and enable it, where really needed, to do what the simple bitters cannot. In general, and especially in nervous, debility, and in functional atony of the stomach and bowels, it is perhaps the best tonic in the world. Secondly, as a laxative, the same requirement, of want of nervous tone—that is, inactivity due to want of nervous power to cause peristaltic contraction—is the important indication for its use, and then it should be associated with locally acting cathartics to provide the required stimulus. Combinations of this sort are among the most satisfactory remedies for chronic or indolent constipation. It is often of great utility in dyspepsia and in atonic diarrhœa, especially in hot countries. Retention of urine, when due to an atonic bladder, is occasionally benefited by it; paralysis is less frequently so. Amaurosis is benefited by it, and it is useful in the debility of alcoholic or tobacco excess. The night-sweats of phthisis and the expectoration of chronic bronchitis are sometimes reduced by its use. It is said to be something of an aphrodisiac, and may be given for sexual debility, especially that of venereal excess. Hysteria, chorea, melancholia, etc., are frequently treated empirically by strychnine with benefit.

Strychnine-poisoning should be met with all the promptness possible; tannin should be given, and, if the case be

seen early enough, emesis should be provoked as soon as possible; this may be done by the administration of apomorphine, mustard, or zinc sulphate. Then chloral and bromide are to be given in large doses, to be followed by inhalations of chloroform. Every cause of excitement is to be avoided as far as possible; and stimulants must be given when needed.

Administration.—Nux Vomica can be given in substance to the extent of one or two decigrams (gr. ij. to iij.) if desired as a tonic; but owing to the difficulty of pulverizing it, and the eligibility of its preparations, it is seldom employed in this way. The abstract (*Abstractum Nucis Vomicæ*, U. S. Ph.) is a solid extract reduced by sugar of milk to a uniform strength just double that of the crude substance. Dose, five or ten centigrams (gr. j.); it is well adapted for use in pills or powders. The older extract (*Extractum Nucis Vomicæ*, U. S. Ph.) varies in strength, but represents eight or ten times its weight of the powdered Nux Vomica. Dose, one or two centigrams. The fluid extract (*Extractum Nucis Vomicæ Fluidum*, U. S. Ph.; strength, $\frac{1}{4}$) is but little employed, as the tincture (*Tinctura Nucis Vomicæ*, U. S. Ph.; strength, $\frac{1}{8}$) is more convenient. Of the official sulphate of strychnine (*Strychninæ Sulphas*, U. S. Ph.) the tonic dose is about a milligram (0.001 = gr. $\frac{1}{60}$); as a spinal stimulant, say twice as much—more than this may be followed by twitching of the muscles—three centigrams (gr. ss.) has proved fatal; five would generally be so. The pure alkaloid, strychnine, though officinal, is seldom dispensed, but is employed in making the citrate of iron and strychnine (*Ferri et Strychninæ Citras*, U. S. Ph.), containing one per cent. of strychnine, and the so-called syrup of the triple phosphates (*Syrupus Ferri, Quininæ et Strychninæ Phosphatum*, U. S. Ph.). Of these the former is seldom, the latter very frequently, employed. Below are the proportions of its ingredients:

Phosphate of iron	133 parts.
Quinine	133 "
Strychnine	4 "
Phosphoric acid	800 "
Sugar	6,000 "
Distilled water enough to make	10,000 "

Dose, from two to five or six grams or cubic centimetres (2 to 6 gm. = ʒ ss. ad ʒ jss.).

Allied Plants.—The genus comprises about sixty trees, shrubs, or twiners growing in tropical Asia or America, many of which are of well-known poisonous properties. Besides the subject of this article, *S. Ignatii* Berg, a climbing shrub of the Philippine Islands, the source of St. Ignatius Bean (*Ignatia*, U. S. Ph.); *S. colubrina* L. of the Moluccas, and *S. Tieuté* Lesch. of Java, and probably others, contain the same poisonous alkaloid. *S. Castelnæana* Weddell, *S. toxifera* Benth., *S. Crévauxi* Baillon, and others in South America are sources of Curare; while still others are used as arrow poisons in other countries. Some species, on the other hand, as *S. potatorum* Linn., and *S. innocua* Delile, are said to be innocent, or even edible; *S. Gaultheriana* is the origin of the Chinese remedy Hoang Nan. The order to which *Strychnos* doubtfully belongs is chiefly tropical, and in its three hundred and fifty species includes but few of medical interest. Among these are *Gelsemium* and *Spigelia*. Baillon considers the *Strychneæ* as a suborder of *Solanaceæ*.

Allied Drugs.—In its special character as a spinal excitant Nux Vomica has not many associates among medicines, although a number are known to the physiologist. Thebaine, one of the minor alkaloids of opium, produces similar convulsions, and it is probable that upon particularly favorable persons morphine itself may do so; but the narcotic effects of this alkaloid are so preeminent that the convulsive power is scarcely ever noticed. Nicotine, gelsemine, buxine, and others are also said to have this property, but in a greatly inferior degree.

As tonic, Cinchona and the simple bitters may be compared with it. See also Curare.

W. P. Bolles.

NYSTAGMUS. This is the name given to that peculiar affection which manifests itself in a continued rhythmical oscillation of the globe of the eye.

It is usually, though not always, bilateral, and when so, the eyes are associated in their movements both in time and direction. The varieties commonly described are the horizontal, the vertical, the rotating, and the mixed. These names are descriptive of the apparent motion of the cornea, and do not denote any radical difference in the character of the disease itself, which in every case is a partial rotation of the globe about the axis of the particular pair of muscles that is affected, or in mixed nystagmus the mechanical resultant of two such synchronous rotations. By far the most common is the horizontal variety, produced by the alternating movement of the external and internal recti muscles. It would be well simulated by keeping the eyes fixed on a distant object which moved constantly from side to side, through an angle of forty or forty-five degrees, and at a rate of one hundred to one hundred and fifty vibrations a minute. The excursion inward and outward is often the same, and the rate of departure and return uniform; but this is not always the case, as the accompanying tracings will illustrate. They are reduced copies from Raehlmann, and are similar to tracings that would be made on a tape that was moving upward over a point on the centre of the cornea at a uniform rate of speed. They are not actual delineations, but are typical of three rather characteristic varieties, which are described by him. Vertical nystagmus is very similar in appearance to the horizontal, except that the direction of the movement is that which would naturally be produced by the superior and inferior recti, and the excursion is less, thus corresponding to the strength of the muscles. The marked difference in appearance between this and the same affection of the obliqui is because the axis of revolution in this last passes through the cornea, so that the conspicuous part of the eye is not displaced but merely turned, showing more distinctly the character and less distinctly the amount of the motion imparted. Nystagmus is not primarily a muscular disease, but must be looked upon as one of the neuroses, similar in very many respects to other rhythmical tremors which affect the hand, the head, and certain other members. As nystagmus is, in the great majority of cases, found in eyes not otherwise perfect, but in which—on account of anomalies of refraction or the refractive media, or from faults of development or diseased conditions of the retina and percipient apparatus—the visual power is far below the standard, it seems natural to explain this incessant motion by the effort of the patient thus to compensate for the impaired function by obtaining the image on two parts of the retina at nearly the same time. This explanation is suggested in a variety of ways. Amblyopic patients will count fingers more readily when the hand is passed to and fro in front of them than when it is held steadily in one position. A star, or other small and indistinct object, is occasionally seen with greater clearness by looking a little away from it for an instant. When looking at the macula through one of the lenses of the ophthalmoscope, its definition is apparently improved by slightly rotating the handle of the instrument so as to displace its image momentarily on the retina of the observer. This theory, which is suggested to a casual and superficial observer, is entirely inadequate to account for the intimate relations and the many analogies that exist between this and other neuroses of central origin. Thus nystagmus, like the shaking of the hand and

Fig. 2525.

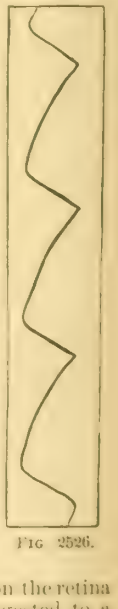

Fig 2526.

head in cases of so-called palsy, usually ceases entirely during sleep. Nystagmus is, too, like the other tremors, occasionally under the control of the will. It is much influenced by mental and emotional excitement. It is varied in its intensity by heat and cold, and other influences that may be brought to bear on the circulatory and vaso-motor systems. It is, like the neuroses of this class, somewhat lessened by small doses, and increased by larger doses of alcoholic stimulants. Its place in a pathological sense is further established by the fact that it may exist in eyes whose vision is in no way impaired, as also by its well-known frequency among the victims of those disorders which seem to be the result of arrested development or hereditary taint. Its anatomical relations are equally significant. It has been produced by passing a current of electricity through the upper portion of the severed spinal cord, also by the passage of a probe into the region of the corpora striata and the optic thalami. It has been noticed after the invasion of the floor of the fourth ventricle by a cysticercus, and it has been associated with sclerotic changes or apoplectic effusions into this immediate neighborhood. It is never intimately connected with lesions of the upper and more peripheral parts of the brain.

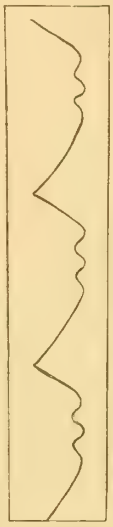

FIG. 2527.

In miners, nystagmus sometimes appears after a period of years, during which they have habitually worked with the eyes in a constrained position. It may disappear after complete cessation from labor, to return again if work is resumed for any length of time; showing in this a striking resemblance to writer's cramp.

Concerning the treatment of this disease there is little to be said, since, with the exception of the few hints that may be gathered from the above allusions to the circumstances by which it is likely to be affected, there is almost nothing to do for it apart from what would naturally be done for the troubles which so often exist in connection with it. Special cases have been found to depend on conditions of the organs of vision that were amenable to change or treatment, and to have improved or disappeared when these were relieved. But for nystagmus itself there seem to be no special indications, as it is rarely cured and rarely disappears. Cases have been reported in which the trouble was dependent on the effort of fixation, in which it co-existed with convergent strabismus and disappeared when that was relieved by a tenotomy, and in which it depended upon binocular vision and disappeared when one eye was covered. The principal interest that attaches to this affection is that which is felt in connection with all unsolved medical problems, and with the use that may be made of it as a means of locating encroaching disease of which it is a symptom.

William S. Dennett.

OAK ORCHARD ACID SPRINGS. *Location and Post-Office,* Oak Orchard, Orleans County, N. Y.

ACCESS.—By the New York Central & Hudson River Railroad to Medina; thence by carriage, six miles, to the springs.

ANALYSIS (J. R. Chilton, M.D.).—One pint contains:

	Grains.
Sulphate of magnesia	1.035
Sulphate of alumina	1.210
Sulphate of lime	4.950
Protosulphate of iron	1.790
Silica	0.130
Organic matter	0.422
Free sulphuric acid	10.370
Total	19.907

THERAPEUTIC PROPERTIES.—The presence of a decided amount of free sulphuric acid renders this water interesting, to say the least. There are only two other such examples in this country—Byron, in the same county, and at Tuscarora, in Canada. There is none in Europe, but several have been found in New Granada, South America.

As an astringent it is useful in hæmorrhages and diarrhœas, and it is said to be efficient in the treatment of chronic ulcers and other sores, used topically.

G. B. F.

OAK, WHITE (*Quercus Alba,* U. S. Ph.). The bark of *Quercus alba* Linn.; Order, *Cupuliferæ,* the common White, or Pasture Oak of North America. "In nearly flat pieces, deprived of the corky layer, about a quarter of an inch (6 millimetres) thick, pale-brown; inner surface with short, sharp, longitudinal ridges; tough; of a coarse, fibrous fracture; a faint, tan-like odor, and a strongly astringent taste," (U. S. Ph.). It is generally crushed to a coarse fibrous powder for medical purposes. In nearly all temperate countries some locally occurring oak is used as an astringent; the British Oak, *Q. Robur* Linn., in Europe (*Quercus Cortex,* Br. Ph.; *Cortex Quercus,* Ph. G.; *Écorce du Chêne blanc,* Codex Med.); the Holly Oak, *Q. Ilex* Linn. (*Écorce du Chêne vert,* Codex Med.), in France and elsewhere. In our own country, also, other species besides the White Oak are sometimes used and were formerly officinal (*Q. coccinea vel tinctoria* Gray, etc.).

White Oak Bark is simply an astringent. It contains considerable *tannic* acid, probably identical with the *quercitannic acid* of *Q. Robur,* and a little coloring matter.

It is used in decoction for cracked or tender nipples, indolent granulations, leucorrhœa, etc., but is seldom given internally.

ALLIED PLANTS, ETC.—See NUTGALLS. The acorns of Q. Ballota (*Gland doux,* Codex Med.) and of other species are also used abroad, roasted and ground, as substitutes for coffee. *W. P. Bolles.*

OATS (*Gruau d'Avoine ou Gruau de Bretagne,* Codex Med.). The common Oat, *Avena sativa* Linn., Order, *Gramineæ,* although a most useful article of food and fodder, is not a medicine, and is only noticed here out of deference to its place in the French Pharmacopœia. It was formerly officinal in the United States and elsewhere, but has been very properly dropped from our Pharmacopœia. The oat differs from the other common grains in the relatively large amount of cuticle and husk of which it consists, making it, when ground and used without hulling or sifting, less completely digestible than the meals of other grains, and partly on this account more laxative; when finely sifted the difference is less marked. A decoction of whole or coarsely broken Oats is slightly diuretic, as are the decoctions of other grasses (COUCH GRASS, for instance). Gruels and porridges for the sick are perhaps more frequently made of oatmeal than other meals, and they are considered, without very good reason, more nutritious. The "*avenin*" of Oats does not differ much from the vegetable casein of other plants.

ALLIED PLANTS, ETC.—See STARCH. *W. P. Bolles.*

OBERSALZBRUNN is a health-resort near Freiburg, in Prussia, which is visited on account of its alkaline-saline springs. It lies in a pleasant valley at an elevation of about 1,250 feet above the level of the sea. There are nine mineral springs in the place, of which three, the Oberbrunnen, Mühlbrunnen, and Demutquelle, are employed chiefly for internal use, the others for bathing. The following is the composition per 1,000 parts of two of these springs:

	Oberbrunnen.	Mühlbrunnen.
Sodium bicarbonate	2.424	1.863
Lithium bicarbonate	0.013	0.007
Magnesium bicarbonate	0.504	0.582
Calcium bicarbonate	0.478	0.584
Ferrous bicarbonate	0.0003	0.001
Sodium sulphate	0.477	0.340
Sodium chloride	0.171	0.085
Organic matters, etc	0.059	0.052
Total solids	4.1263	3.454

There is a considerable amount of free carbonic-acid gas.

The waters of Obersalzbrunn are recommended chiefly in the treatment of catarrhal affections of the respiratory

and digestive systems, gout, and gravel. The waters are employed as drink, in baths, and in inhalations. The whey and herb cures are also used to some extent. The season extends from May to October. *T. L. S.*

OBESITY (*Obesitas*, from *ob*, on account of, and probably *esum*, from *edo* to eat).

Definition.—Obesity signifies an excessive production of adipose matter, which is deposited chiefly in the subcutaneous, intermuscular, and subserous cellular tissues. The largest deposits are found in the nates, thighs, back of the neck, the abdominal subcutaneous cellular tissue, and the mesentery. No such excess is found in the eyelids, penis, or scrotum.

Etiology.—*Predisposing Causes.* Heredity is undoubtedly one of the most important determining influences, as evidenced by the prevalence of corpulence in some families for several generations. Those periods of life in which nutrition is active and muscular exercise deficient are found most prone to excessive accumulation of fat. These are infancy and sometimes middle age, extending to senility. Females are more inclined to corpulence than males, on account of less active habits. Low mental development operates in the same way. The association of excessive adipose deposit with good nature and indolence is correctly explained by supposing the first to be the consequence of the other two, rather than the cause, as is commonly supposed. The influence of race is shown by the prevalence of corpulence among the Hottentots; while the climate of low, moist, and cool regions is found conducive to this condition.

Exciting Causes.—The corpulent are generally, but not invariably, great eaters. Some individuals fatten on any food, but observation shows that fatty and hydrocarbonaceous articles of diet are most conducive to accumulation of adipose. The corpulent are mostly large consumers of water and other beverages. Alcoholic drinks conduce to corpulence so far as they promote digestion and retard oxidation of tissues, by furnishing material for vital combustion and the production of animal heat. In this way beer and the sweet wines are especially efficient. Deficient muscular exercise and excess of sleep diminish the oxidation of tissues and favor accumulation of fat. Hæmorrhages diminish the proportion of red blood-corpuscles and reduce their oxidizing action, so that fat accumulates, unless the bleeding be so excessive as to seriously impair nutrition. Convalescence from prolonged sickness favors the same result by free indulgence of a good appetite and reduced oxidation of tissues from impoverished blood and rest. Deficiency of sunlight retards oxidation by withdrawal of stimulus to all vital processes.

Symptoms.—Under this head are included various associated conditions growing out of accumulation of fat. In some cases large adipose deposit is accompanied with increased muscular development and a vigorous condition of the nervous system, and then a high degree of muscular and intellectual activity is maintained; but such instances are exceptional. Without corresponding muscular growth, augmented weight offers increased resistance and diminished activity of movement, resulting in constant aggravation of the troubles. The heart and lungs are less taxed than in the normal condition, and diminution of function ensues, followed by deterioration of structure. There is unusual tendency to fatty degeneration of various organs, and to sudden death from rupture of the heart or cerebral arteries; while palpitation and dyspnœa from moderate exertion effectually prevent those activities which might, by free oxidation of tissues, reduce the burden. Lowered decarbonization of the blood, by deficient pulmonary action, at the same time depresses the mental operations, and induces somnolence.

Plethora is a sure concomitant of corpulence, and this, coupled with feeble pulmonary action, predisposes to congestions and passive hæmorrhages. Varicose veins, piles, and epistaxis are frequent consequences. Along with the palpitation and dyspnœa before mentioned, we find vertigo, headache, and sometimes disturbances of sight and hearing. The sexual appetite is usually diminished, and impotence or sterility is an accompaniment. Owing to inability to radiate the animal heat readily, the equilibrium of temperature is often disturbed, and a proneness to catarrhal affections of the respiratory and alimentary mucous tracts ensues. The inactive habits resulting from corpulence cause deficient oxidation in retrograde metamorphosis, with retention of urates in the blood and production of gout. Perspiration is usually excessive and acid, causing troublesome chafing and excoriations.

One of the most celebrated examples of obesity was Daniel Lambert, an Englishman, who died at the age of forty years, in 1809. He was five feet eleven inches in height, and weighed seven hundred and thirty-nine pounds. The largest man of whom we have a precise account was Miles Darden, who was born in North Carolina in 1798, and died in Tennessee in 1857. He was seven feet six inches in height, and weighed rather more than one thousand pounds at the time of his death. Until 1853 he was active and able to labor, but after that time never left home except in a wagon.

Pathology.—The fundamental pathological condition is want of equilibrium between assimilation and disassimilation, from excess in nutrition, together with defect in the oxidizing processes carried on by the lungs and kidneys. The heart, though large, is so infiltrated with fat that its action is impeded, and the liver is similarly affected. The stomach and pancreas are larger and more active than the proper nutrition of the body requires. The kidneys, spleen, and lymphatics are small. The blood, though abundant, is generally deficient in red corpuscles, and unfit for carrying the due amount of oxygen required for such combustion of tissues as would repress over-nutrition.

Prognosis.—The conditions coëxistent with obesity are incompatible with longevity. Death may occur without warning in early life from syncope, due to oppression of the heart by the weight of its fatty burden, but oftener in middle age from degeneration in the vascular system. The most common catastrophes of this nature are breach of the cardiac walls and rupture of a cerebral artery.

Treatment.—This consists rather in regimen than in medication. The two objects to be attained are restriction of such food as conduces to accumulation of fat, and increase of the process of oxidation. Those elements of food which contribute to storage of fat, must, as far as practicable, be substituted by other articles of diet. Fatty, saccharine, and farinaceous substances should be avoided, and the appetite must be satisfied with lean animal food, and such vegetables and fruits as are deficient in sugar and starch. At the same time as much muscular exercise as practicable should be taken, for the purpose of increasing the oxidation of all the components of aliment and tissue, both nitrogenous and non-nitrogenous. Disassimilation of non-nitrogenous food must be promoted, to prevent fattening, and of nitrogenous, to prevent accumulation of the urates in the blood. Liability to gout is increased by preponderance of nitrogenous diet. The oxidizing process is facilitated by increase of the red blood-corpuscles, which are generally deficient, so that iron is usually indicated. The alkalies are recommended on theoretical grounds, to combine with fats, either in the food or in the tissues, and also to prevent the production of urates in the blood. Iodine is believed to promote retrograde metamorphosis, and may be used, if well borne. Its alkaline compounds would be the most eligible preparations. Daucal asserts that scammony produces fatty stools, and consequently recommends occasional purging by this agent.

With regard to drinks, all alcoholic liquids should be avoided, except light wines, and these must not be sweet. Tea and coffee must be used in moderation, as they retard oxidation of tissues. Most corpulent persons are greedy of liquids, and water is found both to promote digestion of food, thereby conducing to corpulence, and to increase the excretion of urea, by promoting oxidation. It is therefore important to estimate closely the production of urea, and if this be deficient a sufficient

amount of water must be allowed to bring it to the normal standard. But the ingestion of liquids should be restricted to the amount needed barely to keep up the proper excretion of urea and prevent the accumulation of urates in the blood. Frequent bathing is important, and cold baths are to be preferred, if well tolerated, as they stimulate respiration.

The case and the treatment of Mr. Banting have given name to a plan pursued by his medical attendant, Mr. William Harvey, in 1862 and 1863. Mr. Banting was five feet five inches in height, and weighed 202 pounds. Walking up and down stairs was a difficult feat, and he could not stoop to tie his shoes. Medication by drugs was a complete failure, but by regulation of diet he lost 46 pounds in a few months, recovered his powers of locomotion, and was afterward able to resume his usual diet. The following was the regimen prescribed by Mr. Harvey :

Breakfast.—Four or five ounces of beef, mutton, kidneys, broiled fish, bacon, or cold meat (except pork) ; a large cup of tea without milk or sugar, a little biscuit, or one ounce of dry toast.

Dinner.—Five or six ounces of any kind of fish except salmon, any meat except pork, any vegetable except potato, one ounce of dry toast, fruit out of a pudding, any kind of poultry or game, and two or three glasses of good claret, sherry, or Madeira. Champagne, port, and beer forbidden.

Tea.—Two or three ounces of fruit, a rusk or two, and a cup of tea without milk or sugar.

Supper.—Three or four ounces of meat or fish, and a glass or two of claret.

Black coffee and acid drinks, and fruits without sugar might be allowed, and would be a grateful variation of the limited dietary. Many individuals, however, refuse to submit to the restrictions prescribed, and their relief is therefore impracticable. *S. S. Herrick.*

OBSTETRIC PALPATION. Obstetric or abdominal palpation has been known and practised for a very long time, but never until recently has it been thoroughly appreciated and studied. Wigand, in 1813, was the first to demonstrate its importance ; and after him Schmidt, Hohl, Velpeau, Devillier, Pinard, and others, mentioned the procedure, but it was Mattei who first described abdominal palpation minutely, showing its importance as a means of diagnosing not only pregnancy, but also the position and presentation of the child in utero, and its value in version.

Abdominal palpation enables the physician to appreciate the size of the uterus ; the presence and number of children in utero ; the position and presentation of the child or children ; and, if necessary, it enables him to modify the position of the child in the womb. It is also an aid in determining the existence or non-existence of disease of the uterus or its adnexa.

The obstacles to abdominal or obstetric palpation are : 1, The voluntary resistance of the patient by the contraction of the abdominal muscles ; 2, the presence of abdominal fat, which makes, in some cases, a satisfactory examination almost impossible ; 3, tenderness and inflammation of the abdominal or pelvic viscera ; 4, abdominal and pelvic tumors ; 5, fluid in the abdominal or pelvic cavity.

For convenience of description the abdominal wall is artificially divided into certain areas by two perpendicular and two horizontal lines, the former drawn from the eighth costal cartilage on each side to the middle of Poupart's ligament, the latter drawn transversely at the level of the anterior superior spines of the ilia and that of the ninth costal cartilages respectively. These lines divide the abdomen into nine areas, which are known as the right and left hypochondriac, epigastric, right and left lumbar, umbilical, right and left inguinal, and hypogastric regions.

The Position of the Patient.—The woman should be placed in the dorsal position, with the back slightly raised, the legs flexed on the thighs, and the thighs flexed on the abdomen and slightly rotated outward. The patient's attention should be distracted, and she should be urged to breathe naturally and to keep the mouth open ; a deep inspiration followed by a prolonged expiration will help to relax the abdominal wall if it is at all tense. To engage the patient in conversation is a very good way to draw her attention from herself.

As in all obstetric manipulations, care should be taken to have the bladder and rectum empty. The abdomen may or may not be covered ; but, as a rule, the physician can make a more satisfactory examination if the clothing is entirely removed from the abdominal wall, for under such circumstances tactile sensation is much more acute.

The Position of the Operator.—The operator may stand on either side of the patient, with his face turned toward her lower extremities ; most men, I think, prefer to stand on the patient's right side. The hands of the operator should always be warm, and all manipulations should be made between uterine contractions, if the case under examination is one of pregnancy, and with the utmost care and gentleness, as nothing will be gained by roughness and hurry, and much may be lost or overlooked.

When the hands first touch the abdominal wall its muscles contract and render palpation difficult, or even impossible. To overcome this it is necessary to accustom the surface of the abdomen to the contact of the hands by gentle rubbing, while at the same time the attention of the patient is distracted.

The Time to Perform Abdominal Palpation.—Palpation may be performed at any time, but during the first part of pregnancy it will best be performed in the morning, because, as some authors claim, the abdominal wall is softer and more relaxed at this time. Palpipation should always be made in the interval between uterine contractions.

The Diagnosis of Pregnancy.—This is the most common use of abdominal palpation. The diagnosis may be made by the history of the patient, the physiological tumor bearing a certain relation, as regards size, to the history given, and also by its having intermittent contractions. The uterine tumor in the early months of pregnancy lies deep in the pelvis, in the middle line, and in the later months it deviates a little to the right side. The uterus during the first months of pregnancy does not rise above the superior strait ; in the fourth month it is just rising out of the pelvis and lies in the hypogastric region ; in the fifth month the fundus is between the symphysis and the umbilicus ; at the sixth month it is on a level with the umbilicus ; during the seventh and eighth months, between the umbilicus and the ensiform cartilage ; and at the tenth month it falls to about the same height as it attained at the eighth month.

The tumor formed by the pregnant uterus is globular, firm, but elastic, and situated in the middle line.

How to Determine the Size of the Uterus by Palpation.—The first effort of the physician should be to map out the abdominal tumor by gently passing the hand over the abdomen, beginning below and going upward. If the uterus is still in the pelvis its size and contour can best be made out by pressing the tips of the fingers of both hands deep down into the pelvis, and moving them about from side to side. This should never be done so forcibly as to excite the abdominal muscles to contract.

If the uterus is just rising above the pelvic brim one hand can easily make out its size. Both hands, again, become necessary when the uterus has attained a larger size, and the fundus reaches far above the pelvic brim in the umbilical region. The pregnant uterus has an elasticity peculiar to itself, and may in this way be differentiated from the hard mass of a fibroid or the more elastic cystoma. There are also intermittent contractions in a pregnant uterus which can be appreciated by holding the hand for some time on the abdominal tumor.

To make out the presence of a fœtus in utero our first effort should be made to locate the head, which is the most prominent part of the fœtus, and the one most easily found. Fœtal movements can also be easily appreciated by palpation. As in ninety-five per cent of all

cases the head is in the lower part of the uterus, particularly during the latter part of pregnancy, we naturally look for the head in the pelvis, either at the brim or in the cavity.

The hands should be placed on the abdomen, with the fingers directed toward the symphysis, and pressed gently down into the pelvis; if the head is below, a hard, globular mass will be made out. The breech is, of course, in the opposite pole of the uterus, and can usually be differentiated from the head, but at times this distinction is not so easy to make. The occiput and back of the child, in the majority of cases (seventy per cent.), are directed to the left side of the mother, and we should first look for them in that region. The back is recognized by the greater resistance which it offers to the hand on the side toward which it lies. The position of the back corresponds to the position of the occiput. The extremities or small parts, usually the feet, are found on the opposite side of the abdomen from that on which the back was found, and are recognized by their small size and irregularity of contour, and by the freedom with which they change their position; this movement is clearly made out by palpation, and even by inspection.

In the early months of pregnancy the head may be found in any part of the uterine cavity, and is recognized then by the peculiar sensation which it conveys to the finger. By gentle pressure the head, as well as the breech, may be driven downward or from side to side, to return again in a moment to the hand or fingers held in place on the abdominal wall: this is ballottement.

Diagnosis of Multiple Pregnancy.—In multiple pregnancy the abdominal tumor is larger than usual and more irregular in outline. There is usually a sulcus or depression in some portion of the abdomen. This sulcus always exists when the two children lie side by side or above one another, but it is not always apparent when one child lies behind the other.

Twin pregnancy is usually easy to make out, but the diagnosis may be very difficult when one child lies behind the other. Usually in twin pregnancy one head will be found at the brim of the pelvis, and on palpating the abdomen at the fundus of the uterus another hard globular mass, which has the same characteristics as the mass below, will be felt.

Diagnosis of the Position of the Fœtus.—By the position of the fœtus is meant the relation which certain parts of the fœtus bears to certain bony prominences on the pelvic brim. Thus the position of the vertex is named from the relation which the occiput bears to certain points on the brim. In the first position the occiput is directed toward the left ilio-pectineal eminence, in the second position to the right ilio-pectineal eminence, in the third to the right, and in the fourth position to the left sacro-iliac synchondrosis.

Diagnosis of the First Position of the Vertex.—The hands of the operator, being well warmed, are gently pressed down into the pelvis, and soon meet with the resistance of a hard, globular body, which is the head. The first question would arise: "Is the head flexed or extended?" This is answered by the character of the tumor; if the head is flexed it lies deep in the pelvis, and no part of it is particularly prominent. On the contrary, if the head is extended, the mass formed by the head is very prominent and the back and head are separated by a deep groove, and are not continuous as in cases of flexion. The next question that arises is as to the direction of the occiput. This is determined by palpation in the following manner. If the head is flexed, the occiput, according to Pinard's rule, lies on the side of the globular mass which is deepest in the pelvis. In extension of the head the occiput lies on the side which is highest in the pelvis.

The position of the occiput can be made out by pressing the hand deep down into the pelvis in each iliac fossa, and if the head is flexed the hand which goes deepest is on the side of the occiput; the other hand, of course, impinging on the frontal bone, which lies on a higher plane than the occiput from the mere fact of the flexion of the head. Suppose, however, that the left hand goes deeper than the right, then the occiput is directed to the left. Is it a case of left occipito anterior or left occipito posterior? This can be determined by the position of the back, which can easily be felt if the occiput is directed to the front, but not so if the occiput is directed posteriorly.

The position of the back is determined by the greater resistance which the hands meet with in palpating the abdomen on the side toward which the back is directed. In the first position of the vertex the greater resistance would be on the left side and in front.

The breech is differentiated from the head by its being somewhat softer and less resistant than the latter. The fœtal extremities, or small parts, can usually be distinguished by palpation, during the movements of the child in utero, when they pass frequently under the hand.

The Diagnosis of the First Vertex Position.—When the hands are pressed down into the pelvis they meet with a hard, globular mass, no part of which is particularly prominent. There is no similar mass in the fundus of the uterus, therefore the head must be below, and the breech must be above, in the fundus of the uterus. In this case the left hand, which is on the left side of the abdomen of the patient, goes deeper in the pelvis than the right hand before it meets with resistance; hence, the occiput is directed to the left and in front, for in following up along the left side of the uterus our hand meets with greater resistance than on the right side; this would indicate the presence of the back on the left side and in front, because it is easily made out, which would not be the case were the back directed posteriorly. By careful palpation of the fundus of the uterus the breech can be felt. The feet, or small parts, are felt on the right side, and sometimes their movements can be noticed on inspection.

Diagnosis of the Second Position of the Vertex.—The head is found below in the pelvis, the right hand going farther down than the left, which meets with the resistance of the frontal bone. The back is directed to the mother's right and front, and the small parts are felt in the opposite side.

The Third and Fourth Positions of the Vertex.—In the third position the back of the child is far back in the right lumbar region, and is not easily discovered; in the fourth position the back is in the left lumbar region, and can with difficulty be made out by palpation.

The Diagnosis of Brow and Face Positions.—In face cases the chin is usually directed posteriorly. The extreme extension of the head, which gives rise to a brow or face case, produces a marked prominence of the occipital portion of the head. This prominence of the head and the presence of a deep sulcus between the head and the back make the distinguishing features of a face presentation. When the hands are pressed down into the pelvis, the hard, globular mass—the head—is found below; but in this case the mass rises much higher and is more easily felt than in any of the vertex cases. Between the head and the back of the child is a deep sulcus, which is easily appreciated by palpation.

In the second position of the face the chin is directed to the left sacro iliac synchondrosis, and the brow is in the right iliac fossa. The head is easily felt on the right side, having the same characteristics as when in the first position, and also the same relation to the back of the child.

In the third and fourth positions of the face the chin is directed to the front. The back is not easily felt, and the small parts are noticed moving about in the umbilical region.

Diagnosis of Breech Presentations.—In breech presentation, when the hands are pressed down into the pelvis, they do not meet with the head as in vertex cases, but the mass has a softer feeling, and its outline is much less distinct than that of the head. On palpating the uterus about the fundus the head can easily be recognized by its peculiar hardness. The back is made out by abdominal palpation, as before described. It may be directed to the left or right, and anteriorly or posteriorly. The position of the back indicates the position of the occiput.

The Diagnosis of Transverse Cases is not difficult if the back is directed to the front, but may become so in dorso-posterior positions. In the first place, the outline of the uterus is altered. Its long axis, instead of coinciding with the axis of the superior strait, is directed transversely or obliquely, giving the abdomen much the same appearance which it has when distended with ascitic fluid. The head lies in one or the other iliac fossa, and can be made out in the usual way. The breach is usually not in the opposite iliac fossa, but lies higher in the abdomen, so that in the great majority of cases the child lies obliquely in the pelvis; hence transverse cases are sometimes spoken of as shoulder presentations.

If the back is directed to the front, it can easily be felt by palpation above the symphysis; but if it is a case of dorso-posterior position, the back is not so prominent, but the small parts are seen and felt in the hypogastric region.

The extreme distention of the bladder may be made out by abdominal palpation, and may even be noticed on inspection. This is particularly the case during the latter months of pregnancy, when the large size of the uterus leaves little room for the bladder, which rises above the symphysis pubis, and gives the appearance of a small suprapubic tumor.

Fluid in the abdominal cavity is recognized by palpation. Plastic exudation into the subperitoneal pelvic cellular tissue is easily distinguished by its peculiar hardness. It usually is found in one or the other iliac fossa. Abdominal palpation is useful in some of the obstetric operations, such as fixing and keeping the child in a certain position in the uterus; in performing version; in pressing out the placenta; in insuring complete contraction of the uterus after labor; in fixing and steadying the uterus during the performance of perforation or craniotomy; in forceps cases, and in breech cases, by keeping the uterus well contracted down on the after-coming head. After labor it is useful in giving the physician information in regard to the condition of the uterus and the surrounding organs; whether involution is complete or whether subinvolution exists; also, in the detection of pain or tenderness in or about the uterus.

Charles Ware.

OCCUPATION, HYGIENE OF. From earliest times the effect of occupation upon the life and welfare of the individual has attracted the attention of medical writers, the subject being surrounded with a massive accumulation of literature in all languages.

Although the early writers generally laid great stress upon the nature of the occupation by which the patient earned his living, and although it was with them an almost invariable custom to state explicitly in their clinical histories the trade of the patient, yet no systematic treatise on the subject was written until the year 1713, when that "On the Diseases of Artificers, which by their particular callings they are most liable to," by Bernardini Ramazzini, M.D., Chief Professor of Physick at Padua, made its appearance. This work attracted much attention in Europe, and soon was translated into many different languages. The English translation, now before the writer, is a second edition of 1750, a date which attests the popularity of the work, for in those early days edition did not follow edition with the rapidity to which in the present day we have grown accustomed. Ramazzini's work was not lengthy, forming but one-half of a small pocket volume. The various conditions under which men work are taken into consideration and the various trades are dealt with in order—the metal diggers, the gilders, the chemists, copper and tin workers, etc.

Ramazzini was a very thoughtful observer, to whom we must acknowledge ourselves in no small degree indebted for the foundation of our knowledge of this subject, but his view of the condition of artificers is a gloomy one, and throughout the work there is a tendency to attribute to the trade alone many of the morbid changes which were really the result of the bad hygiene of the period. Since the time of Ramazzini many have written upon this subject. Among those in England may be mentioned Thackrah, who in 1832 published an extensive treatise upon the "Effects of the Arts, Trades, and Professions on Health and Longevity;" and abroad, of the numerous works in print, probably that of Hirt, "Die Krankheiten der Arbeiter," furnishes the most original and valuable information. Lastly, there is that admirable essay on the "Hygiene of Occupation," by Dr. Roger Tracy, of New York, published in the second volume of "Buck's Handbook of Hygiene and Public Health," in which is compressed into a few pages all the useful information scattered through the works of previous authors, as well as valuable original observations, rendering this essay the standard authority on the subject in the English language.

Division of the Subject. — The diseases affecting each class of workmen allow of a classification according to the manner in which their deleterious action takes place. Some noxious agents act chemically upon the tissues, some mechanically by means of the vapors and dusts given off, while others act injuriously by exposure to the weather or by oft-repeated mechanical shock or strain. Ramazzini laid the foundation of subsequent classifications by dealing, firstly, with those subject to chemical influences (metal diggers, gilders, surgeons engaged in mercurial inunctions, chemists, etc.), next those exposed to mechanical exhalations—tanners, tobacco operatives, starchmakers, stonecutters, etc.—and lastly, those whose means of livelihood exposed them to mechanical injuries, sudden or gradual, and to the vicissitudes of the weather, as laundresses, fishermen, porters, grooms, etc., and those whose trade involved overstrain of the sight.

From this nucleus of classification, then, more extensive treatises have grown. Hirt, and afterward Tracy, consider the effects of vapors and gases, next those of dust and of substances in the air, which act by creating irritation or as poisons; and finally, occupations involving exposure to conditions which interfere with nutrition, as elevated temperature, overuse of certain organs, constrained attitude, etc.

It appears to the writer that in a handbook for ready reference, an alphabetical classification of trades and their diseases would best suit the requirements of the reader, who, in taking up this volume, is more likely to be searching for some information concerning the health of a particular class rather than to be seeking a complete and logically divided essay upon the whole subject. In the following pages, therefore, will be compressed, into as small a space as the subject will admit, all the well-known facts concerning the health of workmen of each class, theory and speculation being carefully omitted and prominence being given to those conditions which have been carefully observed and are well understood.

Agricultural Laborers. — Husbandmen probably pass the most healthy lives of all who earn their bread by manual labor. Commonly the offspring of sound country stock, they are hereditarily fitted for their life-work, spending their days in the open air of the country, and in varied and not immoderate physical labor. In America the special danger of the farmer and his family lies in the direction of the digestive system, disorders of which prevail to a very serious extent. This is the result not so much of the bad quality of the food or of its deficient quantity as of bad cooking and lack of variety. Fresh meat, butter, and good vegetables are not often upon the farmer's table, while bread properly aërated is rarely met with. The freshly cooked doughy American biscuit and imperfectly prepared home-made bread, hurriedly eaten, are potent factors in the universally prevalent American dyspepsia. As a proof of this prevalence of digestive disorders in rural parts witness the enormous sale of patent medicines, the "pleasant pellets," "liver pills," and the like, in country stores.

The farmer's wife in America is not the proverbially hearty, buxom woman met with in England, but more commonly is lean and haggard, with sallow complexion, decayed teeth, and disordered digestive and uterine functions. Her reproductive powers are limited, and at forty she is an old woman. "More pitiful wrecks of women, by reason of hard work and poor food, than some of the

farmers' wives of New England it would be hard to find" (Tracy). The writer has had lately under his care in the Montreal General Hospital a case of genuine scurvy, fatal by cerebral hemorrhage, the patient being a young farmer from the eastern part of Canada, near Vermont, who had been living for some months last winter on a diet devoid of vegetables or fresh meat.

Ammonia, Manufacturers of.—Ten parts of ammonia in 100 of atmospheric air can be breathed by men and animals with comparative safety. In larger proportions unpleasant or dangerous symptoms are produced. For the effects of inhalation of ammonia, see vol. i., p. 136.

Aniline Dyers.—Chronic aniline poisoning, see vol. i., p. 232.

Artists.—See *Sedentary Life.*

Athletes.—The athleticism of the present age is, in the opinion of the writer, not conducive either to long life or to the enjoyment of good health. The element of keen and exciting competition which enters into all our outdoor sports and amusements, the pitting of one player against another, or of team against team, of the members of one educational institution against those of another, giving rise to contests carried on with an eagerness wholly out of proportion to the importance of the event, all tend to produce undue exertion of the muscles and over-strain of the viscera, which are bound sooner or later to bring about bad results. Professional athletes (including prize-fighters, wrestlers, base-ball and lacrosse players, gymnasts), are short-lived, have emphysema and hypertrophy of the heart, and a large proportion of them die of phthisis (Tracy), a disease which the writer regards as being the most common cause of death in runners.

Bakers.—Living in a close atmosphere and in a high temperature, bakers are subject to lung diseases, more especially phthisis. Working at night and sleeping by day, they are liable to excessive mental wear and tear, the result of hard work and an irregular mode of life. Hesse, of Leipsic,[1] states that caries of the teeth is so common among bakers that he is often able to tell the profession of the patients by the condition of their teeth. The principal parts attacked are the labial and buccal surfaces, the disease commencing at the neck of the tooth and rapidly extending to the grinding surface. This, he thinks, is due to the inhalation of flour-dust, the caries being caused by the action of an acid which is formed in the presence of fermentable carbohydrates.

Barometers, Makers of.—Chronic mercurial poisoning (see Mercury in this HANDBOOK) is met with among these workmen, but its action is slow. In a case exhibited at the Medical Society of London, in 1872, by Mr. Spencer Watson, the patient had been a thermometer-maker for fifteen years and had resisted the influence of the fumes of mercury for seven years.

Blacksmiths.—Anthracosis of the lungs is likely to be found in those who have spent their time in ill-ventilated forges and smithies, and, as is true of all those who are obliged to make great muscular efforts, aneurism and rupture are not uncommon among them.

Hephæstic hemiplegia (Ἥφαιστος, Vulcan) is analogous to Scrivener's palsy, from which, however, it differs by the absence of spasm and by the progressive extension of the paralysis. It is due to the repeated action of the hammer-arm, and is found in blacksmiths, nail-forgers, pen-makers, and the like. It has been estimated that a penknife-forger delivers as many as 28,800 accurate strokes with his hammer in a day. In the cases reported the patients were young or not past middle life. The symptoms of hephæstic hemiplegia set in usually after an extra effort has been made, when the patient finds a difficulty in keeping up his customary accuracy of stroke. Unilateral convulsions without loss of consciousness are the first alarming manifestation. In other cases without previous warning the right side becomes cold and weak. The facial, lingual, and ocular muscles become involved, and agraphia and aphasia are often present.[2]

The prognosis is unfavorable, the disease tending to spread and gradually involve other nervous structures.

In addition to the nervous disorders blacksmiths are also the subject of catarrhal affections of the respiratory organs. Chronic bronchial catarrh is common, but phthisis, pneumonia, and pleurisy are said to be rare. These effects, together with acute and chronic rheumatism result from habitual exposure to alternations of temperature. The bright light from the forge is said (by Layet) to be productive of eye-affections, chronic blepharitis, presbyopia, and mydriasis with diminished contraction of the pupil. Traumatic ocular lesions occur frequently.

Bleachers.—The amount of chlorine inhaled is harmless, but the continuous immersion of the hands and arms in hot water and strong lye causes cracking of the skin of the hands, and produces an obstinate eruption of an eczematous nature.

Boiler-makers.—The continued din gives rise to deafness, most probably the result of the incessant vibratory impressions upon the membrana tympani, though Roosa considers that the lesion is more deeply seated, involving the fibres of the auditory nerve in the cochlea and semicircular canals.

Bookkeepers.—See *Sedentary Life*; also, consult the article Professional Neuroses, in this HANDBOOK.

Brass-founders.—Brass-founder's ague was first mentioned by Thackrah in 1832, but was more accurately described by Dr. Greenhow in 1862. The symptoms somewhat resemble an imperfect attack of intermittent fever, but the recurrence of the paroxysms is irregular. The attack begins with a feeling of general malaise, constriction of the chest, and sometimes nausea, occurring usually on the afternoon of a day spent in the workshop; at bed-time there is shivering, an indistinct hot stage with a rise in the frequency of the pulse to 100 or 120, followed by profuse sweating. The whole attack is usually slight, but is of frequent occurrence. New-comers, or those who work intermittingly, are more liable to the disease than those continuously employed. The direct cause is generally thought to be the inhalation of the fumes of deflagrating zinc, or "spelter." The drinking of milk is said to exert a prophylactic influence, and the occasional use of emetics is sometimes had recourse to. The prognosis is good, recovery taking place in twenty-four to forty-eight hours, though recurrence is frequent.

Brewers.—Those engaged in the actual brewing suffer more or less from the results of intemperance. They habitually consume large quantities of ale, and gout is common among them. A mischievous custom prevails in some breweries of giving the men a ration of several pints of ale daily, which they drink before going home to their meals. This has the effect of spoiling their healthy appetites, giving rise to indigestion, and in many instances lays the foundation of intemperate habits. Alternations of temperature, and exposure to steam and wet, give rise to frequent attacks of bronchitis and catarrhal affections generally. Those who are employed in the handling of grain are prone to phthisis from the dust. An experience of eight years as medical officer of a large brewery has convinced the writer that phthisis from dust is the prevailing dangerous disease among brewers.

The drivers who distribute the beer barrels at the public houses are very intemperate, taking a glass with each publican they visit, and as a result their lives are short, cirrhosis of the liver being the most frequent cause of death.

Bricklayers.—Lime-dust excites irritation of the conjunctiva and of the skin, but as a rule the occupation is a healthy one. Thackrah quotes an old adage, that "Bricklayers and plasterers' laborers, like asses, never die."

Brushmakers.—The fine animal dust of the brushmaker's shop is peculiarly irritating to the bronchial and nasal mucous membrane. Hirt gives a high percentage of deaths by phthisis. Thus, of 57 brushmakers in various hospitals, forty-nine per cent. had phthisis, while twenty-eight per cent. were suffering from chronic bronchial catarrh.

Butchers.—Butchers are usually strong, healthy, ruddy complexioned persons, with muscular system highly developed, and are generally thought, of all tradesmen, to be least disposed to phthisical disease. They are, how-

ever, prone to suffer from constipation and hæmorrhoids, as well as to become the subjects of tape-worm, from their habit of eating small scraps of raw meat.

Buttonmakers.—The dust given off in the manufacture of bone buttons predisposes to phthisis, but the trade is much more dangerous to health when mother-of-pearl is used. Hirt quotes two foreign writers, Englisch and Gussenbauer, to the effect that mother-of-pearl dust gives rise to an osteo-myelitis, the result of an infarction of the vessels of the bone-marrow with the dust which has entered the circulation. The affection cannot be of common occurrence, for Hirt says that he has never met with a case.

Dr. Crichton Brown[3] mentions, in his essay on "Education and the Nervous System," that there exists among the girls employed in the button-mills of Birmingham a form of chorea, the result of application at their trade. Girls in this state, he says, which generally occurred in those new to the business, might be seen going along the streets after their work was over with their fingers moving involuntarily, as if they still guided the endless procession of buttons, or with their hands jerking aimlessly about. This state is due to an erythism of the centres in the brain for the hands and fingers. In a majority of cases it ultimately subsided without any disastrous consequences; but sometimes it was followed by hysteria or insanity, probably being propagated to other centres; and sometimes it sowed the seeds of brain disease, destined to grow up in after years.

Cabinet-makers.—(See *Carpenters*). There is a special tendency to varicocele (Layet and Koblank, quoted by Tracy).

Cart-drivers.—This class includes coal-drivers, express- and omnibus-drivers, cabmen, and others, who drive vehicles about the streets in all kinds of weather. As a class, they are intemperate and given to that particularly dangerous vice "nipping," or dram-drinking, and are prone to those diseases which are the result of direct exposure to the weather. In the case of cabmen it has been the writer's experience to meet with a large proportion of cases of disease of the spinal cord among this class. It is more than a coincidence that, in a city no larger than Montreal, he should have under observation three cabmen, two of whom have tabes dorsalis and the third spastic paraplegia.

Pneumonia and rheumatic affections are met with, and facial paralysis from cold is frequent.

Caisson-workers.—The caisson disease described by Dr. A. H. Smith[4] depends upon the inhalation of compressed air with, therefore, an excess of oxygen (see Caisson Disease, vol. i., p. 741).

Cattle and Horse Dealers.—See *Grooms.*

Carpenters.—Carpenters and cabinet-makers are extremely subject to varicose veins and frequently have hernia (Tracy). In 1868 Dr. Richardson pointed out the presence of subclavian murmurs in carpenters and in handicraftsmen working in such a manner as to throw the arms forward and draw them backward sharply. He believes that there is not a working carpenter, joiner, or cabinet-maker living in whom the murmur may not be detected. Active exercise with the arms develops the subclavius to such an extent as to modify the natural position of the vessel so that the murmur becomes a permanent, but harmless, phenomenon.[5]

Chimney-sweeps.—Formerly, when sweeping was done by climbing, the occupation was one of the most unhealthy. The sweeps were dirty and very intemperate, their bodies, both inside and outside, being the worse for soot. Ophthalmia was common, while a malignant disease of the scrotum belonged almost exclusively to them. In Thackrah's time many died in youth, and few lived to the age of fifty.

Chimney-sweep's cancer of the scrotum was not uncommon in former days, but now that the business is carried on more by machinery, it has become rare. Structurally, it was an epithelioma of the scrotum, and supposed to be the result of some peculiarly irritating quality in the soot, since among colliers it has not been observed.

China-scourers.—All sooner or later become asthmatical (Greenhow). The female operatives are pallid and chlorotic, and their infants scrofulous. The mortality is enormous.

Clergymen.—As a rule clergymen enjoy a healthy life and have a good expectation. Those with country parishes are of all classes the best situated as regards health and longevity; but such a happy condition of affairs does not exist among the celibate clergy. From an insurance stand-point the lives of celibate clergy are not good risks.

Clergymen's sore throat is a follicular laryngitis and pharyngitis, thought to be caused by the continuous exposure of the open mouth to the drying effects of the atmosphere. The constant irritation of the inflamed soft parts about the vocal cords is apt to be followed by permanent thickening and other changes, as a result of which the voice becomes impaired, hoarseness and aphonia occur, and the throat becomes irritable. There is frequent inclination to swallow and continual efforts are made to clear the throat of phlegm.

This affection of the throat is common among public speakers, barristers, auctioneers, actors, and singers, but it is more commonly met with among the clergy. An ingenious theory to account for this fact has been advanced by Dr. Whipham in the London *Lancet* of 1886. He argues that the difference is due to the fact that the clergyman has to address his congregation from above while the barrister or the actor stand on a level below that of their hearers. Vocalization with chin depressed is more difficult than with upturned face. Another writer in the same journal lays the blame on the ecclesiastical all-round collar, which exerts mischievous pressure upon the thyroid cartilage.

Clerks.—See *Sedentary Life.*

Colliers.—Laborers in coal mines become sooner or later the subjects of anthracosis, that condition known as *miner's lung.* Particles of carbon inhaled for long periods become deposited as solid material in the lungs and set up a mechanical phthisis, manifesting their presence by a peculiar black substance in the sputum. It does not appear that the coal-dust is a direct cause of phthisis, but its presence, by irritation, increases the tendency to pulmonary disease, producing phthisis in a lung disposed to it, and in a sound lung an interstitial pneumonia (Greenhow).[6] Osler regards the disease as consisting of an overgrowth—a hyperplasia—of the fibrous tissue of the lungs induced by chronic irritation, a veritable cirrhosis.[7]

Coal miners lead an unhealthy life, the principal injurious agents being the lack of ventilation in the mines, and the necessity of performing most of their life's work in darkness. Anæmia and chronic nervous irritations are said to result, and scrofula and tuberculosis are common. It must be stated, however, that according to Hirt's statistics the occurrence of phthisis is rare. The miner's life is in addition full of danger from accidents, and the cold and damp to which he is constantly exposed render him prone to bronchial affections and rheumatism.

Miner's nystagmus (C. B. Taylor)[8] is a morbid condition described as peculiar to the coal miners in Nottingham. It occurs in adults independently of other ocular defects, unaccompanied by disease of the nerves or structural change in the eyeball, and is, as a rule, to be noticed only when the patient attempts fixation, especially in a stooping position. It is analogous to writer's cramp, and is due to great and prolonged effort to see in an imperfect light. Change of occupation and working in a good light are all that is necessary to effect a cure.

Commercial Travellers.—The occupation is not healthy. Persons of this class, of necessity, lead irregular lives and are obliged to keep late hours and to spend a great deal of time in overheated, ill-ventilated railroad cars. As a result they suffer from disordered digestive functions, especially constipation. Intemperance in the form of dram-drinking is extremely common among them.

Cooks.—Among male cooks especially gout is commonly the result of continued existence in overheated,

close kitchens, lack of fresh air and exercise, and the constant tasting of rich food. Long standing produces flat foot and varicosity of the veins of the lower extremities. In older cooks ulcers of the legs are frequently met with. Female cooks, such as are employed in private families, are not so likely to be gouty as those employed in hotels, clubs, restaurants, etc., but they suffer in other respects as the men cooks. Eczema of the hands results from constant exposure to wet, and acne of the face is common.

Coopers.—(See *Carpenters.*) An enlarged bursa patellæ (cooper's knee) is the result of pressure exerted by the knee against the barrel.

Copper workers.—Under this heading are included copper-plate printers, coppersmiths, watch-makers and clock makers, and gilders. All are subject to the inhalation of copper dust, as to the effects of which much difference of opinion exists, the weight of evidence being in favor of the view that phthisis is one of the results. The fumes given off in the manufacture of acetate of copper cause acute bronchial catarrhs, sore throats, conjunctivitis, and other irritating effects. It is a question whether the symptoms seen in some copper workmen, to which the name "copper colic" has been given, are not due to the presence of lead. Copper colic is said to differ from lead colic in being attended with extreme prostration and with diarrhœa instead of constipation. The duration is short and the prognosis favorable (Tracy). A copper line upon the gums, similar to the lead line so commonly observed, has been described, but it seems more than probable that it is really a lead line, more especially since in some of the reported cases it was accompanied by colic and paralysis of the extensors.

Cotton Operatives.—The air in cotton factories becomes loaded with fine vegetable dust, peculiarly irritating to the respiratory mucous membrane. This, together with the effects of the sedentary habits of the workpeople, renders phthisis a common disease among them. Indeed, a special form of the disease, *phthisie cotonneuse*, has been described. But modern ideas of ventilation have abolished in great part these dangers. In this town of Montreal, where there are a large number of cotton operatives, we do not observe any unusual proportion of them among the phthisical patients in the hospitals. Tracy doubts the existence of *phthisie cotonneuse* in America.

In addition to irritation of the respiratory passages, Leach [9] reports that the workers in East Indian (Surat) cotton are not infrequently affected with a cutaneous rash much resembling urticaria, and that this appears among the mixers of the raw material. The complexion is usually pale and sickly. The strippers, grinders, and card-room hands mostly suffer from a spasmodic cough, sore throat, pneumonia, and confirmed asthma with oppression of the chest.

Cutlers.—The grinding and filing, more especially of the finer wares, are the most dangerous parts of the trade. The fine dust, metallic as well as mineral, set afloat by the process causes phthisis to an alarming extent. After death from "grinder's asthma" characteristic morbid appearances are found in the lungs, which are studded with small black nodules, from the size of a pin's head to that of a pea, of as yet undetermined composition (Tracy). The mortality among grinders is very high. In twelve cases the average age at death was thirty years and eight months (Holland), and in nine cases it was thirty one years (Schütte, quoted by Tracy). In the manufacture of files, which is carried on to such a very great extent in Sheffield, the file rests in a bed of lead during the process of cutting, and fine lead dust may be seen to rise every time the chisel is struck by the hammer. The men have a habit of wetting the finger and thumb with which they hold the chisel by licking them, moreover, they frequently eat their meals without washing their hands, eating in the workshop. As a result, lead poisoning is the file-cutter's disease (I. C. Hall).[10] File-cutters show a remarkably high rate of mortality from phthisis.

Divers.—The stress of suspended respiration and consequent pulmonary capillary stasis falls on the right instead of on the left auricle and ventricle (Stone).[11] Divers are subject to cardiac hypertrophy.

Domestic Servants.—The occupation is a healthy one. Servants are well fed, usually provided with good bedrooms, and enjoy hygienic advantages unknown to others of the class from which they are recruited. Housemaids and parlor-maids are often anæmic; indeed, most of the cases of anæmia and chlor-anæmia in a hospital are servants. Several causes exist: servants are very much inclined to neglect their diet and to acquire the habit of drinking large quantities of green tea and of eating bread-and-butter to the neglect of meat and fruit. Constant running up and down stairs brings about a state of anæmia which can be cured by rest, good food, and the administration of iron. The work in mounting a staircase is very great, and its injurious effect is intensified by the fact that it is done in a confined atmosphere. The stress upon the vascular system results in feebleness of the circulation and anæmia.

Housemaid's knee is an inflammation of the bursa overlying the ligamentum patellæ, and is commonly met with in those who remain for any length of time upon their knees (see Bursa, vol. i., p. 724).

Domestic servants are frequently the subject of varicose veins, of flat-foot, and of ulcers of the leg, all the result of prolonged continuance in the erect posture. Among parlor-maids and scullions eczema manuum is not uncommon, an effect of constant wetting of the hands. Lastly, it seems that typhoid fever occurs among female servants with great frequency. Many of the fever patients in the female wards in the Montreal General Hospitals are servant-maids, and the same has been observed at the London Fever Hospital, where of the 1,457 cases of typhoid fever admitted, nearly one-third were female servants, most of whom had been in comfortable situations, and many of whom had been attacked shortly after changing residence (Murchison).

Dressmakers.—Long hours, the bent, stooping position and a confined atmosphere render the trade unhealthy. Dressmakers are usually anæmic, and suffer from dyspepsia, constipation, and often hæmorrhoids and menstrual disorders. The eyesight by necessary constant attention is apt to become impaired, but the prevailing danger of the trade is phthisis, partly for the reasons above mentioned and partly owing to the fact that the less strong and robust girls take up dressmaking from a desire to avoid arduous physical exertion.

Dyers.—Eczema of the hands, caused by wet, is intensified by the aniline dyes used in the process. As a rule, dyers are healthy and long-lived, although exposure to a damp, hot atmosphere renders them subject to catarrhal affections and rheumatism.

Electroplaters and Electrotypers.—Constrained attitude in a close atmosphere gives rise to a predisposition to phthisis.

Enamellers.—The silicates of lead used in this process give rise to lead-poisoning.

Engineers.—Changes in temperature give rise to frequent pneumonias and rheumatism, while death from phthisis is frequent (Tracy).

Engravers.—See *Etchers.*

Etchers.—The fumes of hyponitric acid and of nitric acid act injuriously upon the skin. The hydrofluoric acid used in etching on glass irritates and corrodes the skin, causing ulcerations of the hands, and when inhaled gives rise to conjunctivitis, coryza, and bronchial catarrh. The eyes suffer from overuse.

Farriers.—See *Grooms.* Also consult article Glanders, vol. iii., p. 330.

Fellmongers.—Sheep's wool in process of preparing remains soaking in a solution of lime. The handling of wool thus wetted gives rise to most painful and obstinate fissures of the fingers and hands, an effect which may be partially prevented by immersion of the hands in oil or by the wearing of oiled gloves.

Flax and Hemp Operatives.—This occupation is one of the most injurious to life. The dust produced in the process of hackling, carding, line preparing, and tow spinning, contains sandy particles and is extremely irri-

tating. Few escape cough and other lung symptoms, while phthisis is most common. Of 107 operatives whose cases were taken indiscriminately by Dr. Greenhow no less than 79 were suffering from bronchial irritation, and in 19 of these there had been hæmoptysis. Among 27 hacklers (those who separate the coarse part of the flax or hemp from the fine by drawing it through a hackle) 23 were diseased.[12] Even in the time of Ramazini the trade was notoriously dangerous. "Pulvis enim teter ac noxius ex hac materia evolat, ut per os fauces, pulmones subiens operarios ad continuam tussim compellat ac ad asthmaticum passionem sensim deducat."

Gasmen.—The manufacturers of ordinary coal-gas do not suffer from the fumes given off in the process, on the contrary, there is a prevalent but unfounded belief that phthisical patients are benefited by the inhalation of these gases.

Gilders.—Formerly this trade was most dangerous. In Ramazini's time the mercury used in the amalgam made the artificers to "quickly become asthmatic, paralytic, and liable to vertigos; and their aspect becomes cadaverous and ghostly. Their neck and hands tremble, their teeth fall out, their legs are weak and they are afflicted with scurvy." But in the present day the operation of gilding is conducted under cover, so that workmen rarely suffer. The cachexia of mercury will be found much more commonly in the makers of mirrors (see Mercury). Gilders are thought to show a special phthisical tendency. Of the methods to obviate this tendency, free ventilation has been found to be the most efficacious as well as the most practical.

Goldsmiths.—Injurious fumes, from the use of nitric acid in cleaning small articles, give rise to irritation of the conjunctiva and bronchial mucous membrane. The smiths who work at precious metals are prone to phthisis, the result of the confined atmosphere of the shop and of the constrained attitude they habitually assume. Hirt makes out that among goldsmiths three-fourths of all the deaths are due to phthisis, and other observers (quoted by Tracy) have given the proportion as thirty-eight per cent. and twenty per cent.

Glassblowers.—Emphysema may result from the violent expiration. When great efforts are made the tube is passed from one mouth to another with the result of its becoming a means of communicating syphilis from one workman to another. The plan of providing separate mouth-pieces has not proved popular with the men themselves, who prefer the old way with its dangers.

Grooms.—The health of those who work about stables is generally good, the diseases of grooms being mainly the result of imprudence or accident. Two special disorders must be mentioned, viz., horse-vaccine and glanders, to both of which grooms are subject. Of the former the writer has met with two cases in grooms, both men having been in charge of horses affected with the grease, while glanders in man is a disease of much more common occurrence than is generally supposed. The symptoms may easily be mistaken for those of acute rheumatism or pyæmia. In ninety-five per cent. of all cases the patients have been those engaged in the care of infected horses (see Glanders, vol. iii., p. 330).

Hatters.—Mercurial poisoning is said to arise from the use of acid nitrate of mercury, arsenious acid, and bichloride of mercury in removing hair from skins.

An essay on "Hatter's Consumption" has recently appeared in the *New York Medical Journal*, by J. W. Stickler, whose statistics show that pulmonary phthisis is the most common and fatal disease among hatters. The greatest number of deaths occur among the finishers—82.3 per cent. The fur and dust arising during the process of "finishing and pouncing," irritate the air-passages.

India-rubber Works.—The inhalation of carbon bisulphide produces a peculiar train of symptoms, headache, mental depression, impaired sight and hearing, and cramps (see Carbon Bisulphide, vol. i., p. 763).

Lead Workers.—Under this heading are included painters, enamellers, plumbers, typesetters (type metal is an alloy of lead and antimony), and manufacturers of the salts of lead. All are liable to lead poisoning, but more especially those who take part in the dry process of making the carbonate (see Gout, vol. iii., p. 376). Among female operatives abortion is generally recognized as one of the results of lead absorption.

Matchmakers.—Phosphorus fumes exert a very deleterious and peculiar effect upon the makers of matches. The various forms of phosphorus act differently, common or yellow phosphorus being especially dangerous, while red or amorphous phosphorus is innocuous. The evil effects consist in the production of caries of the teeth and necrosis of the lower jaw. The action was formerly thought to be direct and to affect only those whose teeth were already the subject of caries, but there seems to be evidence that cases of necrosis occur in persons whose teeth have been perfectly sound. In the upper jaw the disease is always chronic, but in the lower it is sometimes acute and attended with high fever (Tracy). Though commonly prolonged exposure is necessary, the disease making its appearance four or five years after the person begins work, yet cases occur where very slight exposure gives rise to the most grave symptoms. The writer has placed upon record the case of a boy from whose lower jaw a large piece of bone came away. The only cause to which the disease could be attributed was his trick of holding lighted phosphorus matches in his mouth for the purpose of amusing his companions, and Mr. Salter (in "Holmes' System of Surgery") quotes two such instances. In the one (Pluskal's case) a little girl, seven years of age, was attacked with necrosis of the lower jaw, owing to her habit of playing with matches and discharging them in the dark for amusement; while in the other (Simon's case) the disease appears to have been brought about by a person chewing ginger which had been kept in the pocket along with some lucifer matches.

In addition to these striking and very characteristic effects of phosphorus fumes, match-makers suffer from loss of appetite and dyspepsia and are commonly badly nourished and anæmic. Phthisis is not uncommon. Tardieu and Layet (quoted by Tracy) both assert that phosphorus fumes dull the minds of workmen and take away their energy and heart for labor.

The prevention of these ill results lies mainly in the use of the amorphous or red phosphorus, and secondarily in the free ventilation of workshops and improved hygienic condition of the workmen. The vapors of turpentine, obtained from small tin boxes containing that substance and worn about the neck, have been found to exert a protective influence. Letheby has stated that $\frac{1}{4000}$th part of turpentine vapor in the atmosphere will at ordinary temperatures and pressure prevent the evolution of phosphorus fumes. Good results have followed the placing of vessels containing turpentine in the factories themselves.

Medical Men.—A matter of considerable interest to medical men themselves, this subject has engaged the attention of many writers, who have however, been unable to agree among themselves. As a rule, an optimist view has been prevalent from the time of Ramazzini, who says that medical practitioners are exempt from ordinary diseases in consequence of their good exercise and their "hilarity of mind" when they go home "bene nummati," with their fees in their pockets, but that they are subject to hernia from going up-stairs and catch dysentery from sitting beside their patients. Thackrah considers night-calls less injurious than the public and profession suppose, for if, he says, we observe those who for thirty or forty years have been engaged as accoucheurs, we shall find them as robust as others. The statistics of Dr. Guy, published some forty years ago, showed that the average life of the learned professions collectively was seventy-six and a half years, and he gave to medical men the highest position. Dr. Farr's statistics, as given in the Thirty-fifth Report of the Registrar-General, yield a result thus expressed: "Physicians and surgeons from youth up to the age of forty-five experience a mortality much above the average; after that age they do not approach the priesthood in health but differ little from the average.

Many young practitioners have hard struggles to encounter. They are in contact with the sick, are exposed to zymotic disease, and their rest is disturbed. In states of depression acutely poisons are at hand. There is an excess of practitioners in cities. Country practitioners have to visit their patients in all weathers, at all hours. The causes from which the medical men suffer demand careful study."

Within the present year (1886) some startling facts concerning the life and health of the members of the medical profession have been brought to public notice, in a paper read by Dr. Ogle before the Royal Medical and Chirurgical Society. According to his tables the mortality is not only high, but it is increasing. In 1880, 1881, 1882, it was higher than that of any of the other callings and professions; not only that, but it was higher than that of medical men twenty and ten years before. "While the mortality of the legal profession in 1880-81-82 was 20.23 per 1,000, and that of the clerical profession only 15.93, that of the medical profession was 25.53. Compared with other callings—with trades not very favorable to health—the medical profession is more deadly. Thus, the mortality of medical men is greater than that of teachers of the same age, commercial travellers, bakers, shoemakers, printers, bookbinders, masons, and coal-miners. It is less than that of innkeepers, brewers, butchers, earthenware manufacturers, cotton, woollen, and worsted manufacturers, painters, plumbers, glaziers, cutlers, and quarrymen."

The information given by Dr. Ogle as to the causes of death is of the very highest interest. Medical men die in much larger proportion of the same disease than do other men of corresponding age. The two figures after the disease mentioned show the deaths per 1,000,000 of medical men, and of all other men respectively: Scarlet fever, 59, 16; typhus, 79, 38; diphtheria, 59, 14; enteric fever, 311, 238; malarial fever, 46, 11; erysipelas, 172, 136; alcoholism, 178, 130; gout, 91, 78; rheumatic affections, 251, 215; malignant diseases, 879, 790; diabetes, 284, 108; diseases of the nervous system, 4,565, 4,268; diseases of the circulatory system, 4,142, 2,934; liver disease, 1,744, 744; other diseases of the digestive system, 973, 632; calculus, 86, 30.

The mortality from phthisis and diseases of the respiratory apparatus is low. Of the non-fatal diseases to which medical men are peculiarly exposed must be mentioned syphilitic infection from contact with specific discharges in surgical and obstetrical practice. That this occurrence is frequent there can be no doubt, if an estimate can be formed from the number of cases which have come within the limited experience of the writer. The victim of such an accident naturally keeps his misfortune a secret, so that the knowledge of the existence of such cases is not easily obtained.

Among pathologists poisoned wounds are not uncommon, resulting in some well-known cases fatally, and in many most seriously. The wounds received in the dissecting-room are very rarely of consequence. The writer, with eight years of experience as a teacher of practical anatomy, has never seen any serious consequences follow dissection-wounds.

Anatomical tubercle is a name given to a form of warty growth occasionally seen upon the hands of dissectors and morbid anatomists.

The use of carbolic and other solutions in antiseptic surgery, involving the continual dipping of the hands in medicated water, renders the skin harsh and dry, favors chapping, and is productive of an obstinate eczema in some persons, similar to that met with in domestic servants and washerwomen.

Millers.—The irritation of flour-dust seems to act more injuriously externally than internally. Millers, provided they are not intemperate, do not incur any special risks to life. A form of eczema mammum is found among them, due to the irritation of the flour; and acne, furuncles and blepharitis ciliaris are extremely common (Tracy).

Miners.—(See also *Cutlers.*) Mr. Simon[13] states that with one exception the 300,000 miners in England break down, as a class, prematurely from bronchitis and pneumonia, caused by the atmosphere in which they live. The exception is most important. The colliers of Durham and Northumberland, where mines are well ventilated, do not appear to suffer from any excess of pulmonary disease, or do so only in a slight degree (Parkes).

The lead miners suffer greatly. According to Hirt, out of 2,000 Saxon miners 1,743 were poisoned, and almost all had a blue line upon the gums.

Under the title Miner's Anæmia, Perroncito[14] described an anæmia which occurs among the miners of St. Etienne, and which resembles closely the disease observed among the workmen at St. Gothard tunnel. But the disease was found to depend on the presence of an intestinal parasite, the *anchylostoma duodenale*. Miner's anæmia has thus been shown to be a parasitic, and therefore a preventable, disease.

Mirror-makers.—Mercuric poisoning, giving rise to cachexia with tremors, is present. In the case of an Italian, aged forty-two, who was treated in the London Hospital,[15] the metal was thought by the patient to have entered the system through the palms of the hands and under the finger nails, the vapor having also been inhaled. He had silvered mirrors for twenty-one years, but his first attack of poisoning had not occurred until he had been at it fourteen years.

Women are more subject to the evil influence of the mercurial vapors than the men, and, as in other metallic poisonings, abortion is common. The children born are often weak and unhealthy, and die early.

Meyer's plan of prevention has yielded the best result, viz., to keep the floors of the workrooms sprinkled with ammonia; also to shorten the hours of work, to keep the shops well ventilated, and the workmen scrupulously clean. Meals should not be eaten in the factory.

Nail-makers.—See *Cutlers* and *Blacksmiths.*

Painters.—Lead-poisoning is common, but in addition painters are subject to headache, dyspepsia, and general muscular weakness, which has been thought to be due to the inhalation of the turpentine fumes.

Photographers.—The life is sedentary. Cases of poisoning have been reported from the use of crystals of cyanide of potassium to rub off the stains of nitric acid.

Plumbers.—It has not been proved that plumbers suffer from inhalation of sewer-gas. Gout is an indirect effect of the lead-poisoning to which plumbers are subject (see Gout, vol. iii., p. 376).

Potters.—Emphysema is so common as to be designated potter's asthma. The dust given off in the sifting and mixing of clay, as well as in the removal of inequalities of the surface in substances already baked, causes an irritation of the lungs. Lead poisoning results from the enamel used in the preparation of porcelain, and is not very uncommon.

According to Varrentrap (quoted by Hirt), the health of potters is not so bad as writers assert. Of 1,000 living potters but 98 entered hospital in a year, of whom but sixty-two per cent. suffered from internal complaints. In comparison with many other trades, blacksmiths, coppersmiths, locksmiths, tinsmiths, this amount of sickness is small, which is the more worthy of remark since many of the workmen exist under essentially better conditions than the potters.

Printers.—Phthisis is prevalent, especially among the compositors. Twenty-five per cent. of them die of it (Tardieu). This is the combined result of bad air, lack of exercise, and an habitually constrained attitude. More recent figures go to show the excessive mortality prevailing among the members of this craft. Statistics are given in *The Printer*, a trade journal (quoted in *The Lancet*, February 9, 1884), concerning the funeral allowances, which for the year 1883 amounted to 74. Out of this number 22 compositors died from phthisis, and 13 from bronchitis, etc. (probably phthisis also), thus giving a total of 35 deaths out of 74 to diseases of the respiratory organs.

Cracks and fissures of the lips and small tumors on the interior of the mouth, result from the printer's habit of putting type into his mouth.

Pianists.—See article on Professional Neuroses.

Publicans.—Of all occupations, those connected with the retailing of alcoholic drinks are the most unhealthy, for very few of this class are not the subjects of alcoholism in some of its forms. Dram-drinking is the most injurious form of intemperance. Visceral disease, especially of the liver and kidneys, is most prevalent. The returns of life assurance companies carry out this assertion: In those of a large English company now before me, it is stated that there were 513 persons directly engaged in the liquor trade whose lives were insured in the company at the beginning of a quinquennial period. At the end of that time 123 had died; 180 had allowed their policies to lapse or had surrendered them; and 210 were still on the books. It appears as the result of a comparison between the ages at death of these 123 publicans, that the mortality was more than twice as great as that which had prevailed among the members of the company generally. Looking, then, at the causes of death, it appears that this class die especially from diseases of the nervous, digestive, and urinary organs. Of the 123 deaths, no less than fifty per cent. are traceable to these causes. The class of *digestive diseases* which the actuary makes, includes diseases of the stomach and bowels, ulceration of the bowels, disease of the liver, hepatitis, and jaundice; these killed 20.32 per cent. of publicans, while of the whole number of the assured, 10.35 per cent. died from these causes; 8.13 per cent. of the publicans died of diseases of the kidney and bladder, against 4.40 per cent. of the non-publicans (see Life Insurance).

Quinine, Manufacturers of.—The dust or vapor in quinine factories gives rise to a peculiar rash, the nature of which is variously described. The most reliable information on the subject is that furnished by Dr. J. F. Weightman, whose observations were made upon the workmen employed in the chemical factory of Powers & Weightman. Only new workmen are affected, and in the majority of cases one attack protects against another. The vapor from boiling solutions seems to be the chief cause, it being rare for anyone to have it if working in the dry materials. About ninety per cent. of the workmen are affected. The rash follows severe itching, and finally develops into eczematous vesicles, which soon burst and form crusts, the parts attacked becoming swollen.

Rag-sorters.—Among the rag-sorters of the Continent, more especially in Eastern Europe, a peculiar condition of a septicæmic character has been observed to occur. Such an outbreak occurred lately [16] in a paper manufactory at Ligat, in the Russian Baltic Provinces. Of fifty-six women employed in the sorting of rags, five were seized with the disease on April 25, 1886, and seven on the 28th. Five cases had already proved fatal, one of them in twenty-four hours from its commencement. In almost all cases the symptoms were similar. The attack began with a rigor, in some with rapid rise of temperature, great depression, and headache, rapid respiration, distressing cough, thready pulse and a fall of temperature. After this improvement set in, or else the patient showed signs of collapse with an imperceptible pulse and a subnormal temperature, but without delirium. Death occurred on an average, in less than six days. The post-mortem changes did not indicate any special lesion. The committee entrusted with the investigation of the outbreak reported that the disease was of an infectious description, but of its exact nature doubts exist, some authors asserting that it is simply anthrax or charbon, others that it is of a nature entirely different from that disease.

Sailors.—Phthisis is the prevailing disease, the result of damp, and of the confined atmosphere of the forecastle.

Salesmen and Saleswomen.—As with waiters and others who have to stand for any length of time, those who serve in shops suffer from varicose veins, ulcers, and eczema of the legs, and share in common with those who have to work in confined atmosphere a liability to chest diseases. Pains of a special character in the feet are met with in shop women, possibly due to tension of the ligaments, and menstrual disorders are common.

Scavengers.—Scavengers, including sewer men and privy-cleaners, enjoy fairly good health. No writer has been able to find any disease prevalent among them as a class; in fact, Parent du Chatelet [17] attempted to show that the workers in drains and night men are particularly exempt from fever. Murchison,[18] however, takes an opposite view. Scavengers and dustmen are not particularly exposed to drain effluvia, after all, but workers in obstructed drains are particularly likely to contract disease, and, indeed, typhoid fever would be more common in this class of laborers were it not that most of them are above the age most liable to it, and that some may be prevented by previous attacks, and still more by the fact that lengthened exposure to the exciting cause diminishes the risk of infection.

Scourers of Cloth.—Inhalation of the vapors of benzine and turpentine produces headache, lassitude, and other nervous disorders.

Seamstresses.—See *Dressmakers* and *Sewing-machine Workers.*

Sedentary Life.—Under this heading are included all those whose living is gained by the exercise of their mental talent, entirely apart from bodily exertion, such as lawyers, notaries, solicitors, artists, clerks, students, teachers, and literary men generally.

Diseases of the blood-vessels are common. Hæmorrhoids is the special disease of the notarial profession and vascular changes of a more serious character occur in the cerebral circulation. Many literary men have died of cerebral hæmorrhage and its consequences, notably Dickens, Thackeray, Trollope. Dr. Johnson was aphasic and so was Swift.

In persons of this class a highly-strung nervous organization is present, and there is a general neurotic tendency. Insanity and genius are not far from each other, many of the greatest of literary geniuses having been insane or having exhibited in a high degree the craving for stimulants. Cowper was insane, Swift's reason deserted him, Porson, the great Greek scholar, was a drunkard, and Byron was decidedly eccentric.

The digestive process is carried on in a sluggish manner, dyspepsia is most common and constipation the rule. The reader will remember what trouble poor Carlyle's digestive apparatus gave him. The portal circulation is tardy, and this, together with long sitting, aids in the production of piles.

Urinary difficulties occur at the latter end of life, enlargements of the prostate, old strictures, and stone. Sir Isaac Newton, for example, died of stone, and the case of Louis Napoleon is recent.

But gout is the disease of the sedentary life, and in one form or another many are attacked. Of its causes nearly all are at work; deficient bodily exercise, an animal diet, and indulgence in the good things of the table, all conduce to this result. Sydenham consoled himself during an attack with the reflection that gout killed more wise men than fools.

Sewing-machine Workers.—Although the sewing-machine has been accused of being the cause of various uterine disorders and of mechanically exciting the nervous system, yet increasing experience in its use has not verified the predictions of its early detractors. As used in families its effect upon health seems negative, while in factories the agents for evil are not the sewing-machines themselves but the vitiated atmosphere and the necessarily sedentary nature of the employment. More particularly is this true of the present day when in nearly all factories where sewing-machines are used the motor-power is supplied by steam instead of by the feet of the operatives. Nichols [19] reports, after considerable investigation, that a young woman may use the sewing-machine daily for three or four hours without detriment to health, that the illnesses which most frequently prevail among professional operatives making use of the treadle are: Indigestion, attributable particularly to the unhealthy conditions under which they pursue their occupations; muscular pains of the lower limbs from the long-con-

tinued and frequent use of the same muscles, diseases peculiar to women, aggravated rather than caused by the plethoric condition of the pelvic organs. As favorable a view is taken by Eulenburg, Blaschka, and Ohausen,[20] the latter holding that the exercise of the sewing-machine when carried on in good air is of advantage to the digestive and respiratory system. Importance is attached to the kind of chair used, that it may readily accommodate itself to the movements of the body. Dr Ohausen found no consumptive tendency among the many sewing machine workers he has attended, and goes so far as to consider that the work may even neutralize a tendency in that direction.

Shoddy Grinders.—These workpeople are employed in the picking and tearing of woollen rags, afterward manufacturing them with the addition of new wool into yarn. The tearing machines or "devils" produce much dust. Girls and boys are generally employed in sorting the rags. Shortly after entering upon this form of employment they are attacked with headache, sickness, dryness of the fauces, and difficulty of breathing, to which collection of symptoms the term "shoddy fever" has been given. The more acute symptoms subside in six or eight hours, but cough and expectoration remain as a chronic condition. The sorting does not appear to be an unhealthy employment. Hirt even speaks of it as being cleanly, but it is the dust which gives rise to all the evil effects.

Shoemakers.—The effects of bad posture, combined with a sedentary life and close atmosphere, render shoemakers liable to headache, loss of strength and appetite, constipation, and hæmorrhoids. The digestive process is sluggish. A peculiar depression of the sternum, due to the pressure of the last has been observed, but is not constant. Scrotal eczema has been thought (by Layet) to prevail among cobblers. Corvisart and Merat (quoted by Tracy) thought them specially liable to chronic gastritis and gastric cancer, and Morgagni to popliteal aneurism. The use of a leaded lapstone on which to hammer the leather has been known to produce the symptoms of plumbism (Hall).[21] Cobblers, it has been observed, are prone to think as they work, and have been included with the tailors, and flax weavers, in what has been termed the "contemplative" class of tradesmen. Very many cobblers have risen to distinction, the shoemaker has always been fond of a "supra crepidam" career, and from the last have arisen a host of thinkers, poets, preachers, and politicians.[22]

Smelters.—The dangers of smelting depend upon the character of the mineral operated on, the wasting of arsenical and mercurial ores being especially dangerous. Poisoning by mercurial fumes generated in this process manifests itself in either an acute or chronic form. When acute it resembles the condition seen when one of the compounds of mercury is ingested. The most striking characteristic is the acute and violent stomatitis. But by far more common are the chronic effects. The gums become swollen, and the teeth loosened, until one by one they drop out. Layet (quoted by Tracy) states that at Almaden and Idria one sees young men of twenty and thirty with wizened faces, toothless gums, and a horrible breath. Those exposed to the fumes of mercury are likely to suffer from a peculiar form of tremor, known as mercurial tremor, which may be sudden or gradual in its onset, and is usually unaccompanied by salivation (Merat, quoted by Anstie). At first there is mere unsteadiness of the arms, increasing to a general muscular tremor which extends over the whole system, until eventually even the muscles of mastication and deglutition become involved. This is the first degree of the disorder, and it is usually curable if taken in time. Other nervous phenomena, insomnia, darting pains in the limbs, muscular spasm, paralysis of the extensors, and general mental feebleness, mania, and idiocy have been attributed to the action of the metal. Some constitutions appear capable of resisting the influence of mercury many years, while others succumb almost immediately.

At the present day such precautions have been taken as almost to do away with the possibility of mercurial poisoning, so that it has become a rarity.

Metallic poisoning is not common among the smelters of arsenic in well-kept establishments. The symptoms described as occurring are vomiting, diarrhœa, nasal catarrh, vertigo, and general debility with emaciation. Papular, vesicular, or pustular eruptions, with a tendency to ulcerate, are often present. The bad results of arsenic smelting may be obviated by ventilation and personal cleanliness.

Soda.—Manufacturers of soda suffer from the inhalation of hydrochloric acid fumes, the result being an anæmic condition, with hot, dry skin and bronchial catarrh. The work causes thirst, which makes the workman drink large quantities of water and thereby diarrhœa is set up, and the teeth may suffer from the irritant action of the gas upon the enamel.

Soldiers.—To attribute any particular disease to the effects of the military service is scarcely possible. The conditions of service vary greatly in different nations, and in the same army according to the nature of the service and the country in which it is performed. The short service system, which in modernized armies now prevails, has done much to ameliorate the hygienic welfare of the soldier. The old soldier of fifteen and twenty years' service with the colors no longer exists. Intemperance and venereal disease still remain as the difficulties for the military hygienist to overcome. Phthisis was, at least in English armies, in former times most prevalent, but latterly, since it has been conclusively shown that the mortality from this disease diminished as the cubic air-space per man was increased, the death-rate from this cause has greatly diminished. The loss of life in armies from scurvy, malaria, and dysentery, has been reduced to a minimum of late years.

Among old soldiers, aneurism of the thoracic aorta is common. This the writer believes to be the result not of the hardships of the service, but of the syphilis which so often figures in the clinical history of the old soldier (see Aneurism). In the infantry the amount of aneurism is slightly below that of the cavalry, but not much so (Parkes). The greater prevalence in the artillery and cavalry has led to the idea that its development is due to the prolonged and violent exercise of the arms in gun-drill and the sword exercise.

For a description of the "irritable heart" of soldiers read "Heart Strain in the Military Service," vol. iii., p. 573.

Stone-cutters.—Injuries of the eye from flying particles of stone are common. Phthisis affects this class with unusual frequency.

The cutting of mill-stones is the most dangerous part of the trade, the particles given off being of a penetrating and irritating nature.

Straw-hat Manufacturers.—These are exposed to the inhalation of sulphurous acid, though rarely in a dangerous degree. Lead poisoning may result from the inhalation of the dust brushed off the hats, after they have been immersed in solution of calcium sulphide and dried (Tracy).

Tailors.—The ordinary journeyman tailor works in a close atmosphere, usually with very many others. A system known as "sweating" prevails in Europe. The sweating-dens of the east end of London and other towns are overcrowded and unsanitary, and the clothes made in them are at times contaminated. Such establishments are potent means of spreading infection. Tailors suffer from the effects of their sedentary life (see *Shoemakers*). Bursæ are said to form on the outer malleoli, and on the fifth metatarsal bone. Professional spasm is not uncommon.

Tanners and Leather Dressers.—Eczematous eruptions may be caused by the local action of the fluids in which the hands are immersed. Arsenical eruption, too, may be present in those who use a mixture of lime and orpiment in the vats in which the leather is dressed. Lead poisoning has been found among the manufacturers of patent-leather. There is also a certain amount of danger from malignant pustule, especially for those who handle skins from Oriental countries. It was formerly thought that tanners enjoyed a complete immunity from

consumption. Thackrah "carefully inquired at several tanyards, and could not hear of a single example of this formidable disease."

Tea-tasters—In tea-tasting the strong infusion is merely taken into the mouth, not swallowed; nevertheless nervous effects have been observed in the form of muscular tremors. It is said that persons can rarely follow this calling longer than seven or eight years (Tracy).

Tobacco Operators.—When the shops are well ventilated the preparation of tobacco is a healthy occupation, but when dust is present health suffers, catarrhal affections of the respiratory apparatus and phthisis being among the results. In cigarmakers a decided lack of fecundity has been observed. There is a retardation of sexual development in young girls who enter the factories before the sexual evolution has begun (Tracy). In 337 families visited in New York, there was an average of but 1.63 children to each family. Frequent miscarriages may account for this lack of children. Nicotine has been found in the urine and in the amniotic fluid of cigarmakers.

Type-setters.—See *Printers* and the article Professional Neuroses.

Watchmakers.—Professional spasm is not uncommon. The fingers and thumb become affected, owing to the continuous work at picking up and readjusting minute screws.[23] Phthisis is very prevalent. Of 200 deaths among the watchmakers at Besançon, 127 were from phthisis (Perron).

Wool-sorters.—A special form of blood-poisoning has been noticed among those engaged in the sorting of alpaca, mohair, camel's hair, and dry Eastern wools. The work is especially dangerous when the disinfection of the raw material has been neglected. Such cases are from time to time reported in the journals by those who practise in the English manufacturing districts. The symptoms are often obscure, but all point to a severe form of blood-poisoning. In one case (*Lancet*, October 12, 1882) a filler of boxes with brown raw mohair observed a papule on the outer border of the right radius, which became enlarged and inflamed, the sloughing extending up the arm. Death occurred after six days' illness. In another case, reported in the same journal, no outward lesion was noted, but the patient, after sorting some mohair not previously disinfected, was seized with what was considered a severe cold, attended with congestion of the lungs. In both these cases the bacillus anthracis was found in the blood after death; indeed, the disease is generally regarded as one of the forms of anthrax. *R. L. MacDonnell.*

[1] Quoted by London Lancet, October 9, 1886, from the Deutsche Monatschrift. [2] Smith, Frank: London Lancet, vol. i., 1869, p. 427.
[3] The Book of Health, p. 333. London, 1883.
[4] The Effects of High Atmospheric Pressure, including the Caisson Disease. Brooklyn, 1873.
[5] Medical Times and Gazette, vol. ii., 1868, p. 443.
[6] Greenhow: London Lancet, vol. i., 1869, p. 604.
[7] Canada Medical and Surgical Journal, vol. vii., p. 454.
[8] London Lancet, vol. i., 1875. [9] Ibid., 1863, p. 648.
[10] The Medical Press, Nov. 8, 1865. [11] Lancet, Dec. 13, 1879, p. 864.
[12] Mr. Simon's Fourth Report to Privy Council, quoted by Parkes.
[13] Fourth Report of the Medical Officer of the Privy Council, 1862.
[14] Lancet, January 21, 1882. [15] Ibid., vol. ii., 1868, p. 798.
[16] Ibid., October 2, 1886.
[17] Du Chatelet: Rapport sur le Curage des Égouts. 1829.
[18] Murchison: The Continued Fevers of Great Britain.
[19] Third Annual Report of the State Board of Health of Massachusetts.
[20] Lancet, August 30, 1884. [21] Ibid., vol. i., 1876, p. 894.
[22] Lives of Illustrious Shoemakers, by W. E. Winks. New York, 1883.
[23] Weir-Mitchell: American Journal of the Medical Sciences.

ŒSOPHAGUS, DISEASES OF THE. The œsophagus as an organ presents a singular immunity from disease when compared with the other organs of the digestive tract. While we may find diseases of the same nature in the gullet, as in other viscera lined with mucous membrane, they are, nevertheless, much less liable to be thrust upon our notice. This may in a measure be explained by the anatomical fact that the œsophagus is simply a short dilatable tube, whose lining is of tough epithelium, and which is fixed in a vertical position in the body. Another element is the vague, often trifling, character of the symptoms of the milder œsophageal lesions, which may be merely complications of more tangible disorders.

In considering the subject we shall discuss: (1) the diseases of the œsophagus, (2) foreign bodies in the œsophagus, and (3) operations for the relief of these conditions.

Inflammation of the Œsophagus. — (Œsophagitis) may arise under the same conditions as do inflammations of other mucous membranes.

Etiology.—Very rarely the mucous membrane of the gullet is subject to an acute catarrhal inflammation, of idiopathic origin, or consequent upon exposure to cold and wet. Such a liability is said to occur especially in rheumatic or gouty subjects (Cohen). Occasionally, pharyngitis or gastritis may extend to the œsophagus; or neighboring inflammatory conditions, wholly outside of the mucous tract, may involve the mucous membrane of the organ; such are, *e.g.*, vertebral caries, or abscess from degeneration of the mediastinal or bronchial glands. Œsophagitis may occur as a complication of the acute exanthemata, of cholera, typhus, or other disorders, attended by intense febrile conditions. Rarely diphtheria and the stomatitis (thrush) of infants may involve the œsophagus. By far the most common excitant of œsophagitis is, however, the ingestion of irritants. These may be alimentary, food which is too highly seasoned or which is too hot or too cold; or they may be of a corrosive character, acids or alkalies (perhaps undiluted medicines); or the irritation may be due to the continued presence of a foreign body. Syphilis may, at times, excite a form of inflammation here, but of this little is known.

Varieties. — With the varied causation we may have several different pathological conditions in œsophagitis. The more usual forms are acute and chronic catarrhal inflammation. Œsophagitis is very apt to be accompanied by desquamation of the epithelial layer. With the severer cases this may result in extensive loss of tissue and ulceration. Certain poisons (especially tartar emetic) and small-pox cause a variety of œsophagitis in which characteristic pustules form in the lining of the organ, and we have, therefore, pustular œsophagitis. Pressure by a foreign body or by the pathological enlargement of a neighboring part, or degenerative changes resulting from local or general disease, may terminate in gangrene of portions of the œsophageal wall—gangrenous œsophagitis. Traumatic inflammation results from instrumental or other violence, and from the ingestion of corrosives. Chronic œsophagitis follows the acute form, or may be chronic from the first, when due to a long-continued use of hot foods, and, perhaps, alcohol.

Pathology.—The opportunity for post-mortem examination of mild cases of acute œsophagitis rarely occurs, and except when the changes are considerable the inflammation is not readily detected, whatever may have been the appearance before death. Microscopic examination will show proliferation of cells and infiltration of the stroma in the sub-epithelial layer. With severer cases there will be found patches denuded of epithelium, and often ulceration. After corrosive poisoning the lesions may be very extensive. In the follicular and pustular varieties there are present typical changes. Pustules or swollen and infiltrated follicles are scattered irregularly over the surface. There may be small ulcers resulting from the breaking down of the tissue.

Foreign bodies lodged for some time in the tube will excite inflammation, which may terminate in ulceration. Phlegmon may occur in the cellular tissue about the œsophagus, commonly as the result of deep ulceration. This peri-œsophagitis may be diffuse or circumscribed, and the pus may be infiltrated or in the form of a distinct collection. The mucous membrane will be protruded by the swelling, and will be congested, or, perhaps, show points of ecchymosis. The epithelium may, by this process, be destroyed over a considerable area, and the resulting ulceration may then be very extensive. When the inflammation has become chronic, the mucous membrane will be thickened and congested, and in such cases the lower third of the organ is usually the part most extensively involved. The hypertrophy may extend to the surrounding cellular tissue, and may even involve the muscular coat. There are usually found cicatrices of former

ulcers, or active ulceration may be present, and the mucous membrane is often gathered in folds, in the interstices of which considerable quantities of tenacious mucus are found.

Symptoms.—In mild cases a diagnosis of œsophagitis is seldom made with certainty, for the symptoms in such cases are so vague in character and so trifling as to fail entirely to attract attention. Then again, occurring as a complication of a severer disorder, its signs are hidden by the graver symptoms. In cases of moderate severity dysphagia, eructation of mucus, and more or less pain are the prominent symptoms which point to inflammation in the gullet. The addition of blood, pus, and shreds of mucous membrane to the regurgitated matter, and an increase in the severity of the symptoms, mark a case of deeper gravity. Dysphagia, especially after taking fluids (Mackenzie), is always present with the lesion. The intensity varies greatly, as in mild cases it is scarcely to be noticed, and in severe cases absolutely prohibits the taking of food at all. There is also pain of a dull, steady character, referred to the sternum. Spasm of the œsophagus may occur as a result of the irritation of the parts, and food may be regurgitated, and with it mucus, or mucus mixed with blood. The appearance of pus or of shreds of mucous membrane will denote a more serious form—gangrenous or phlegmonous inflammation. The escape of a quantity of pus indicates the rupture of a peri-œsophageal collection. Febrile or other constitutional symptoms arising from the œsophagitis are not usually severe, though in the phlegmonous variety or in peri-œsophagitis from perforation the febrile symptoms characteristic of suppuration are present. Auscultation does not afford much assistance in diagnosis, though there are said to be adventitious sounds accompanying the normal during deglutition.

Prognosis.—The outlook in acute catarrhal œsophagitis is favorable. The disease is commonly self-limiting and lasts one or two days, or, perhaps, a week. It may pass into a subacute or chronic form. As a complication it is seldom severe in itself, but may be serious as a concomitant of a disease already taxing the endurance of the patient. The swallowing of corrosives is usually followed by a severe type of inflammation upon which ulceration is apt to supervene. The severest cicatricial contractions follow this form of œsophagitis. The follicular and pustular inflammations are not apt to produce marked after-symptoms. Chronic œsophagitis is intractable, and commonly remains uncured. It is apt to result in dilatation or constriction of the organ, the former condition coming from weakened walls and the latter from the cicatrization of ulcers.

Treatment.—When the disease occurs in a mild form, little is needed in the way of treatment. Fluid diet, demulcent drinks, and quiet, the latter secured by the use of opiates, if necessary, form the essentials of treatment. In case of traumatic inflammation, caused by the presence of foreign bodies, or by the ingestion of corrosive substances, the indication is clear to remove the offence or to neutralize it chemically as soon as possible. The severe inflammation that follows demands more active treatment. In this case food by the mouth, even the blandest, must be avoided. Hot or cold applications along the course of the œsophagus will relieve pain in some cases, counter-irritation in others. Fragments of ice swallowed may not cause pain, and will help to allay the inflammation. The skin and the rectum must replace the usual avenue for the reception of food and medicine. Topical applications will probably be of very little value, and any instrumental interference, as by the stomach-tube, is to be deprecated, except when absolutely demanded by the indications. Chronic œsophagitis offers more opportunity for treatment of its concomitants, stricture, etc., than for its own cure. Constitutional causes must be, as far as possible, removed. Indulgence in alcoholic beverages cannot be tolerated. Syphilis must be treated by the iodides, and, indeed, their use is recommended even in non-specific cases of circumscribed œsophagitis. Topical treatment is of little value.

Ulcer of the Œsophagus is a result of inflammatory processes, and is similar in appearance and nature to corresponding lesions elsewhere. The depth of the ulceration varies from a simple loss of the mucous membrane to actual perforation of the tube. Such perforation may extend to a neighboring organ—the pleura, pericardium, trachea, or a blood-vessel.

Etiology.—The special elements in the etiology of ulcer are found to be the swallowing of corrosive substances, stricture, impacted foreign bodies, the breaking down of tumors, instrumental violence, varicose conditions, and syphilis.

Prognosis.—The slighter erosions of the mucous membrane alone heal readily, and leave no marked traces. With the severer lesions the results are more to be dreaded, and the prognosis must be guarded. The nature of the cause and the severity of the initial inflammation will, in a measure, guide the prognosis. The danger of perforation of the walls, and the excitation of peri-œsophageal cellulitis or abscess, and of perforation of neighboring organs is not to be disregarded. Ulcers may excite adhesion of the œsophagus to parts about, and in this way "traction diverticula" (Fig. 2528) are formed. They may, and often do, result in stricture by contraction of the cicatrix after healing.

Fig. 2528.—Traction Diverticulum of the Œsophagus, representing the adhesion between the œsophagus and the trachea. (Mackenzie.)

Symptoms.—Frequently ulceration gives rise to very slight symptoms. We have already seen that symptoms of inflammation may be mild, and ulceration may modify them but slightly: the pain may be increased, the dysphagia may be more marked, and there are more apt to be febrile symptoms. The more distinctive element in diagnosis is hæmorrhage. The bleeding may be only slight or may be severe, but the appearance of blood in the vomited or expectorated matters renders a diagnosis of ulceration probable. The passage of a bougie, if one cares to try it, will help to confirm the opinion by localizing the painful spot.

Treatment.—Rest for the part by restricted diet, or, if necessary, by total freedom from use and by a resort to the rectum for feeding is important. If the hæmorrhage be severe, we may use ergot internally and astringents and ice by the mouth. Applications of nitrate of silver, belladonna, etc., may be made, if considered desirable, by means of the cupped bougie. Bismuth subnitrate is sometimes given by the mouth, and with good effect (Mackenzie). The use of the sound from time to time is advised by some to prevent contraction of the cicatrix, but is as strongly condemned by others for fear of perforation of the œsophageal wall.

Deformity of the Œsophagus is met in a considerable number of individuals, and especially in those who have suffered from previous injury or disease of the organ. The malformation may be (1) of congenital origin or may be (2) secondary to some previous lesion.

1. *Congenital deformity* is rather a pathological curiosity than a lesion of value from a therapeutic stand-point. The explanation of the origin of the defects lies in the abnormal closure of the branchial clefts in the fœtus. The malformation may be only slight, as a moderate thickening of the walls at some portion and consequent rigidity, or there may be atresia by a membrane. The more marked deformities found are diverticula, dilatation of the entire tube, double œsophagus, or absence of the whole or a part of the organ.[1]

The infants usually starve very soon, and but little can

be done for their relief. Where the malformation is only moderate in degree, as in the case of slight constriction or diverticle, the subject may go on to old age without very serious trouble.

2. *Acquired deformity* is secondary to inflammation in almost every case, if we except malformations of cancerous origin. The lumen of the tube may be widened or narrowed, that is, we may have dilatation or stricture of the œsophagus.

Dilatation may be diffuse or localized. The diffuse or fusiform dilatations are not usually very wide, but often involve almost the entire length of the tube. They may, however, be very large, so that the organ is distorted so as to be almost as large as the stomach (Fig. 2530). Localized dilatations are commonly sacciform. These sacculated dilatations or diverticula, while commonly small, may attain enormous size (Figs. 2531 and 2532).

Etiology.—Stenosis precedes dilatation in almost every case. The rationale of the distortion is easily explicable. Food passes to the constriction and is delayed or entirely stopped, and the parts above are stretched more and more until the food is expelled. Gradually there occurs a resultant dilatation which may be pouched, or may be fusiform if the distention involves a considerable portion of the organ. A strain of the wall, by instrumentation or by the deglutition of a large bolus or other mechanical violence, may result in rupture of some fibres of the muscular coat. The small defect becomes larger by renewed attacks in swallowing, until the mucous coat is pushed out and a pouched diverticulum results. Foreign bodies or external pressure may produce sufficient stenosis to cause dilatation of the tube. Diffuse dilatation may result from constriction at the cardia, from paralysis of the muscular coat, or from degeneration consequent upon chronic inflammation. Peri-œsophagitis or ulceration may, during the process of repair, excite adhesion of the œsophageal wall to some neighboring organ, and the result is the formation of a pouch which is known as a traction diverticulum. Figs. 2528 and 2529 show such a diverticulum, which was observed post-mortem in a man who had died of cancer of the gullet. No connection could be found between the two affections. The adhesion occurred three and one-half inches below the cricroid cartilage. The diverticulum admitted the tip of the little finger, and was eleven millimetres in depth.[2]

Fig. 2529.—Traction Diverticulum of the Œsophagus. The organ has been split so as to show the opening of the pouch. (Mackenzie.)

In some cases congenital malformation may remain until adult life, and give rise then to symptoms for the first time.

Pathology.—Diffuse dilatation is usually moderate in amount, and does not excite severe symptoms. When the organ is dilated there is usually chronic œsophagitis, as a cause or as a result of the trouble. In extreme dilatation of the entire tube there is in almost every case degeneration of the muscular coats, the simple mechanical distending force not being usually sufficient to stretch the organ to such dimensions. In the case[3] selected for illustration (Fig. 2530), the dilatation is very unusual. The calibre of the œsophagus reached the size of a large arm, and the length was increased nearly one-half, so that in life there must have been more or less pouching of the walls. Dilatations are commonly found above strictures, and are then not usually of large size. Diverticula are now and then very large, though not commonly larger than a hen's egg. In cases of large diverticula the openings may become very wide, and in this way food may tend to fill them rather than the stomach, and the filled diverticulum may press upon the gullet so as to hinder food from entering the organ. Figs. 2531 and 2532 represent side and rear views of an enormous diverticulum, which was apparently of congenital or traumatic origin.[4]

These diverticula often contain foreign bodies, and may become ulcerated by their presence. They occur most frequently in the upper part of the gullet, but may be found at any portion.

Symptoms.—These are primarily mild, but increase as the dilatation becomes larger. There will usually be difficulty in swallowing, slight at first, but increasing from time to time. The portions of the food which do not reach the stomach will be regurgitated after a longer or shorter period. Habitual rumination may result in this way, and the food is swallowed again and again, until it finally reaches the stomach. There may be decomposition of the food in the sac, and then there is an escape of ill-smelling food and foul gases. Occasionally the dilatation may be felt as a tumor in the neck; usually on the left side, occasionally on both. The contents of the sac may be forced into the pharynx by pressure. A bougie passed into the œsophagus will often catch on the margin of a pouch and may pass into it. Much care and a good stock of patience are often necessary to pass instruments in these cases. The smaller diverticula, especially in the lower portion of the tube, will rarely give rise to sufficient symptoms to attract attention. The diagnosis must, in many cases, be reached by exclusion, if at all. Auscultation is not of value in diagnosis, for, though the sounds will be abnormal, there is no one which can be considered characteristic.

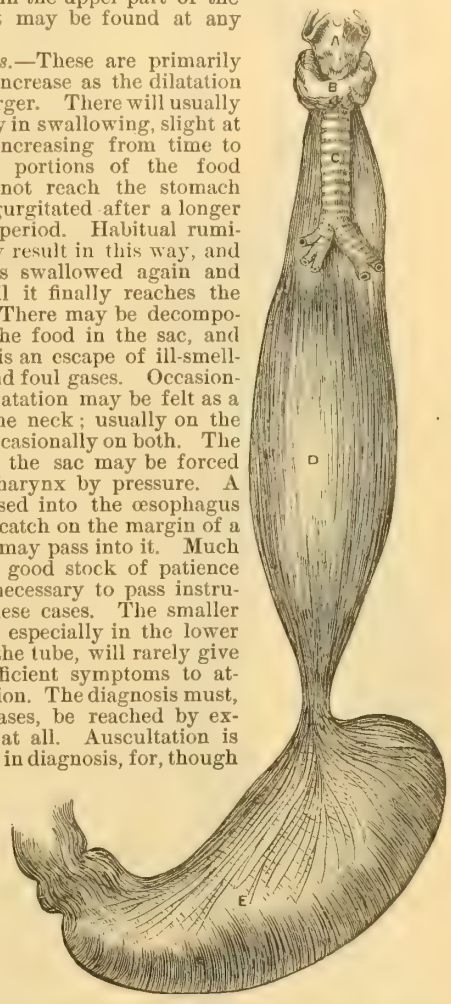

Fig. 2530.—Extreme Diffuse Dilatation of the Œsophagus. A, larynx; B, thyroid body; C, trachea; D, œsophagus; E, stomach. This occurred in a woman, fifty years of age, who had suffered for fifteen years from symptoms referable to chronic œsophagitis. Death resulted from cancer, but not of the œsophagus. The distance from the cricoid cartilage was 29 ctm. (11¼ inches), while the extended organ measured 46 ctm. (18 inches). The maximum circumference was 30 ctm. (11⅔ inches), and the greatest cross measurement 14½ ctm. (5⅔ inches). The cardiac opening was not constricted.

Prognosis.—Dilatation, *per se*, is not often the cause of death. The stricture, which is usually the cause of the sacculation, is much more apt to shorten life. Still, in some cases, diverticula prevent food from reaching the stomach and inanition results, or the pouch forms a suitable spot for ulceration, and perforation may readily follow. With care in the selection of proper food, however, and with cautious feeding, patients may live for a long time. Death occurs soon when there is much difficulty in feeding.

Treatment.—This refers to the cause, especially when

a stricture or a foreign body is behind the dilatation. Prevention of the lodgement and decomposition of food is of prime importance. This may be accomplished by the use of fluid or semi-fluid foods. Perhaps the stomach-tube may be required in order to feed the patient, and, if rendered necessary on account of the difficulty of passing the tube, a small permanent tube may be kept in place for a considerable time. Rectal feeding may be needed. Electrical stimulation may be of service in conditions of paralysis, but it should always be used with great care. Operations for the removal of diverticula have as yet no history. Early gastrostomy is justifiable in many of these cases, and is demanded by malnutrition.

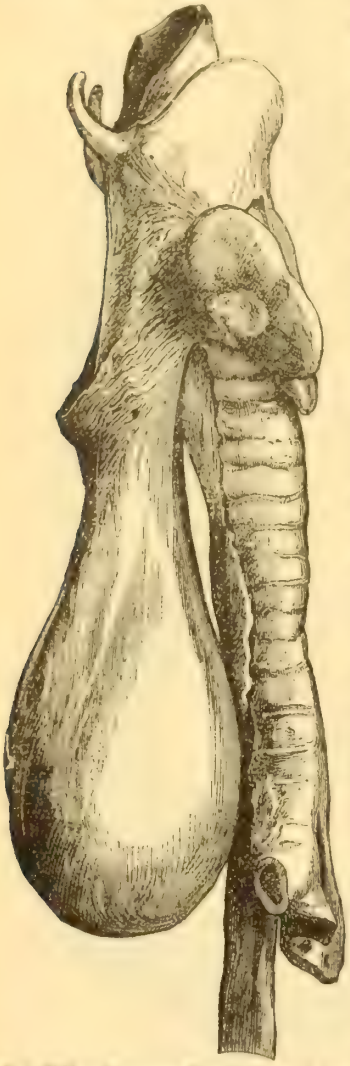

Fig. 2531.—Enormous Diverticulum of the Œsophagus. The subject from whom the preparation was taken was an old man, and death resulted from inanition caused by the diverticulum. The opening to the sac was nearly as large as that of the gullet, and it was caused by the yielding of the inferior constrictor of the pharynx. The sac reached a lower level than the bifurcation of the bronchi; its length was 12 ctm. (4¾ inches). (After Koenig.)

Stricture is, perhaps, the most common form of œsophageal disease which is seen by the physician. For the purpose of simplification we may classify strictures under the heads of (1) cicatricial, (2) cancerous, and (3) spasmodic. Besides these forms we may find stenosis in the gullet from other causes, which are so unusual as to demand only casual mention. Extrinsic pressure, as by goitre, enlarged lymph-glands, aneurism, or cold abscess, may obstruct the gullet. Intrinsic conditions, *e.g.*, foreign bodies, benign tumors, and sacculated diverticula, may narrow its lumen. Syphilitic stricture does occur, though it is rare. Constriction of congenital origin is of infrequent occurrence. Life is not usually prolonged under conditions of malnutrition in the infant, but Ziemssen cites three cases in which persons have reached old age under this disadvantage.[5]

1. *Cicatricial stricture* results from the healing of lesions accompanied by a loss of substance. These lesions are in almost all cases, as we have seen, due primarily to the ingestion of corrosive substances. Loss of substance may follow wounds of the organ, inflicted internally, by rough foreign bodies or instrumentation, or contraction may result from bullet- or operation-wounds externally. The character of the cicatrix is determined by the amount of the surface lost, and the depth to which the loss of substance extends in the wall. If a large area be superficially involved, the healed surface is smooth, but may be corrugated more or less by contractions in the scar. The deeper ulcers, involving the submucous and muscular coats, are followed by dense, unyielding cicatrices.

Pathology.—Cicatricial stricture is most often found near the pharynx or near the cardia, though it may occur anywhere in the tube, a point at the level of the diaphragm being a favorite intermediate position. The strictures are commonly single but may be multiple. The form of the stricture depends upon the character of the original ulceration. It may be longitudinal or annular, and may involve almost the entire length of the œsophagus. The obstruction offered by the stricture will present wide variations from slight inconvenience to complete occlusion in some cases. Above the constriction there is apt to be dilatation, and more or less inflammation of the mucous membrane, with or without ulceration.

Diagnosis.—A history of gradually increasing dysphagia after injury of the gullet by caustics or other irritants, particularly occurring in a young person, points

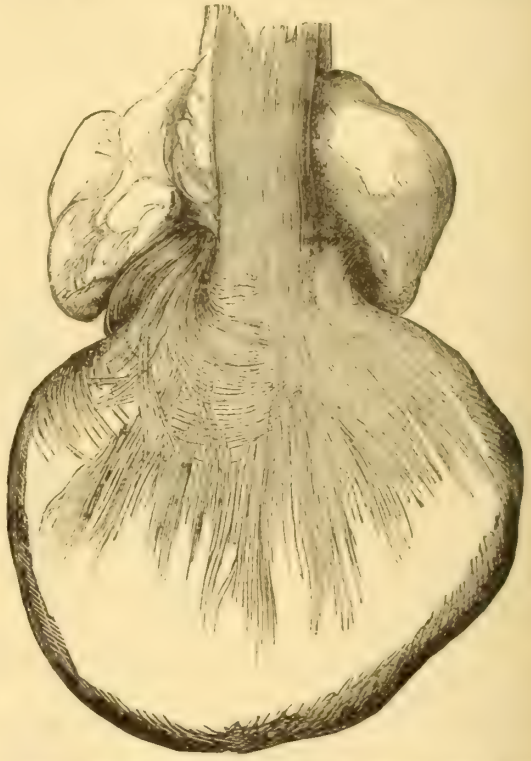

Fig. 2532.—Diverticulum of the Œsophagus. Posterior view. (After Koenig.)

to cicatricial stricture. This history may be obscure when the accident has taken place in infancy. Spasm and pressure stenosis are to be excluded by careful questioning and physical examination. The cautious exploration of the œsophagus with a bougie-à-boule will usually clinch the diagnosis.

2. *Cancerous or Malignant Stricture.*—Cancer of the œsophagus may be primary or secondary to growths elsewhere, the primary being the more common form.

Etiology.—As elsewhere, the cause of cancer is obscure. Repeated mild irritation is reputed to favor the disease, and among the most common irritants are said to be alcoholic beverages, too hot or too cold food, and the like. It is very questionable, however, whether the disease is ever caused in this way. Heredity has been considered a factor in some cases, but here, as in cancer of other organs, the matter is open to debate. The pre-existence of a simple stricture which has become cancerous is rather to be regarded as a coincidence than as a factor in the causation. Tuberculosis and cancer of the gullet are found together in a considerable number of patients, but this seems also to

be a mere coincidence. The disease occurs more often in men than in women, and, in almost all cases, after the age of forty. Why men should be more prone to the disease is difficult to understand, but the statistics of a large number of cases seem to show it—for example, Mackenzie, in 100 cases, found 92 of forty years of age and upward, and 72 men; Ziemssen, in 53 cases, 48 over forty years of age, and 43 men. Secondary cancer is not of frequent occurrence in the œsophagus, except by direct extension from the neighboring parts, as the tongue, pharynx, larynx, or stomach. It is not often involved by metastasis from distant organs.

Pathology.—The form of primary cancer found in the œsophagus is the pavement-celled epithelioma. The tumor is lobulated, and usually quite friable. If of rapid growth it will be soft and succulent. Microscopic examination shows the alveolar arrangement of the cells and stroma, and here and there the pearls or nests of epithelial cells which characterize this class of cancer. Rarely, colloid carcinoma originates in the gullet (Mackenzie).

The lower third of the organ is most frequently involved, next the middle, and least frequently the upper third. The favorite sites are at the cardiac extremity, opposite the diaphragmatic opening, and at the point of crossing of the left bronchus. Metastatic deposits are found in the deep cervical glands, but the tendency is to involve the neighboring organs by extension rather than more distant ones by metastasis. Ulceration is frequently very rapid and may end in perforation of, or adhesion to, neighboring organs. This rapid ulceration occasionally relieves the obstruction temporarily by reopening a passage for food.

Diagnosis.—Cancerous stricture is indicated by the presence of increasing dysphagia in men of mature years—forty or over—who give a history of progressive stenosis and cachexia. Enlarged and indurated glands should be looked for at the root of the neck. The regurgitated matters will often contain blood and pus, and fragments of typical epitheliomatous tissue may be detected. When the œsophagus is secondarily involved, the existence of the original cancer will insure a diagnosis. If instruments are used, great care should be observed, as the tissues are degenerated and softened and there is great danger of perforation.

3. *Spasmodic stricture, or œsophagismus*, is a condition which may be described as a clonic, spastic contraction of the muscular coat of the œsophagus, usually of hysterical or hypochondriacal origin, or due to reflex stimuli.

Etiology.—As a pure neurosis, spasm occurs most often in women under forty years of age. It may occur in women who present other hysterical symptoms, or may be the sole neurotic manifestation. In persons of a nervous temperament, who have, or think they have, been bitten by dogs, œsophagismus may follow as a symptom of pseudo-hydrophobia. As a reflex it accompanies inflammation of the œsophagus, the ingestion and impaction of foreign bodies, and, occasionally, laryngeal or tracheal lesions. In certain individuals it may follow the ingestion of hot or cold, or a peculiar kind of, food. More rarely it is a reflex from irritation in the gastro-intestinal or genito-urinary system, or may complicate rheumatism or thoracic lesions. It may occur as one of the symptoms of rabies or tetanus. One attack may end the occurrence, or they may be repeated from time to time for many years.

Pathology.—The affection consists in spasm of the circular fibres of the œsophageal muscle, and no post-mortem traces of the condition are to be found. The upper and lower portions of the tube are most frequently involved.

Diagnosis.—The sudden onset of the attack and its occurrence in neurotic subjects, usually young persons, will indicate the probability of spasm. The introduction of a large œsophageal sound will usually reassure the patient, and often a single catheterization will effect a cure. The maintenance of the nutrition and the absence of cachectic symptoms will aid in the exclusion of more serious obstructions. Auscultation during the deglutition of fluids will show that the obstruction is not absolute.

The symptoms of stricture of the gullet are quite distinct. We have inability to swallow ordinary food and its regurgitation. The age of the patient is of importance in guiding our diagnosis of the kind of obstruction. The amount and rapidity of bodily emaciation will help to determine the severity and progress of the constriction. With regard to the dysphagia, it may be partial or complete. A patient may be unable to swallow solids, or solids unless in small masses or when followed by fluids, or, finally, there may be total obstruction even to fluids. Regurgitation may be occasioned by, or may occur after, each attempt to take food. The frequency with which it occurs will help in determining the degree of patency of the canal. If the regurgitated matter be of alkaline reaction the indication is that it has not reached the stomach. The food may be retained for some hours, or the regurgitation may take place immediately after swallowing. The retention will indicate dilatation above the stricture. It is said that when the stricture is in the upper portion of the gullet the ejection follows more closely upon taking food.

Pain is a symptom of slight practical value. It may or may not be present. Intense pain may accompany a spasm, and yet the symptom may be absent in a case of real gravity.

The œsophageal bougie will locate the obstruction, and a careful examination will define the site, calibre, and length of the stricture. The utmost patience and gentleness must be practised in these examinations. Auscultation is of considerable value here, for either the normal sound will be replaced by the slow trickle of fluid or all sound will be wanting. The site of the obstruction may also be determined in this way.

The prognosis varies with the kind of stricture. In spasmodic stricture almost all the patients recover, though death has occurred in a few cases from unconquerable spasm. The duration of the attacks depends upon the cause, and upon the patient's willingness to submit to treatment. If hysterical in origin there may be repeated attacks. Reflex spasm may be very persistent, and may be the last of a series of symptoms terminating in death.

In cicatricial stenosis the prognosis must be cautious. If the stricture is dilatable there is a very good chance of cure, provided the area of the stricture is not too great. If the contraction is not progressive, life may be prolonged indefinitely by care in diet. Gradual closure and inanition are chapters in the story of many a case which is too often closed by ulceration, perforation, and death.

In cancer the prognosis is always very bad. The duration of life is about one year after discovery, though it may be a little longer. Death results from inanition and exhaustion, from ulceration and perforation, or from metastatic deposits in other organs.

Treatment.—When the stricture is passable and of cicatricial or spasmodic nature, the passage of the bougie for dilatation will be of service in most cases. The use of bougies should be frequent at first and gradually discontinued. The moral as well as the mechanical effect of the sound in spasm is usually excellent, and a few catheterizations with a large instrument are sufficient to cure the attack. In some cases the most persistent use of bougies will not suffice to dilate cicatricial strictures. Under these circumstances various forms of dilators have been passed upon guides within the strictures, and forcible dilatation attempted. It has, however, not proved a popular operation, nor has great success followed the use of dilators. When the stricture is passable, but narrow, a slender, soft-rubber tube has been passed through the nose or mouth and left in position. In some cases life has been prolonged from forty to three hundred and five days by the use of such a permanent stomach-tube.[6]

Rectal and endermic feeding should be practised to their limits. Pain should be relieved by morphine, and it is best administered by the hypodermic needle, as the other avenues are already overtaxed. The further measures which may be practised are surgical attempts to provide an opening through which food may enter the

stomach, by internal or external œsophagotomy, œsophagostomy, or gastrostomy. In the case of cancer we are still more limited in our means of palliation. The permanent tube may be used, but will probably only stimulate the growth. Resection has been practised (œsophagectomy), but the cases have not yet been sufficiently numerous to enable us to form a satisfactory judgment of its value. Gross[7] cites five cases, of which two survived the operation for five and seven months respectively. As the only means of averting certain death, even for a time, it may, if undertaken early, become a valuable addition to our resources. Œsophagostomy and gastrostomy are the only other measures to prolong life, and they do not promise much. The average duration of life in the cases of recovery from these operations, when done for the relief of cancer, is only about a month; and one-third only of the operated cases are classed among the recoveries.

Tumors in the Œsophagus.—Aside from cancer, which we have already discussed under the title of stricture, we very rarely meet with other forms of growth which are of pathological interest.

Sarcoma has been reported in a very few instances. In each case the growth was at the upper orifice of the canal.

Lipoma occurs rarely in the form of small, polypoid growths.

Fibro-myoma sometimes occurs. Here, as elsewhere, it tends to take the form of a polypus, and may attain considerable size and assume curious branching forms.

Cysts occur rarely, but are not suspected until after death, as they are commonly small and give rise to no marked symptoms. They may be cysts by retention, formed by occlusion of the orifices of the mucous follicles, or dermoid cysts from faulty closure of the branchial clefts.

Treatment.—The rarity of the occurrence of these affections renders their diagnosis very questionable. They do not, as a rule, give rise to symptoms. Occasionally, large sessile fibro-myomata have been vomited into the pharynx, and have then caused symptoms which first called attention to them. They have been removed under these circumstances by the snare and by forceps. In one case a ligature was passed about the base and the tumor was allowed to separate and come away by the rectum.

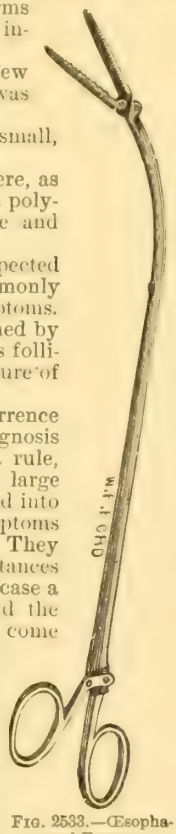

Fig. 2533.—Œsophageal Forceps.

Foreign Bodies.—The impaction of foreign bodies in the œsophagus is of quite frequent occurrence. The fact that the upper orifice of the alimentary canal is its narrowest part is of value in excluding many of the larger foreign bodies, and the strength of the pharyngeal muscles helps to impact many of the pointed masses before they enter the gullet. A complete list of the articles which have been lost in the gullet would rival for variety the catalogue of a pawnbroker's sale. They may almost all be classified, however, under the headings of smooth and pointed; and one can hardly cite an object of suitable size which has not its analogue in the completed list. To cite a few (modified from Koenig,[8] *Deutsche Chirurgie*):

1. Sharp or pointed bodies: pieces of bone, fish-bones, needles, thorns, fragments of broken pottery and glass, false teeth and palate-obturators, fish-hooks, knives, forks, scissors, etc.

2. Smooth surface: soft—pieces of meat, living animals (mice, frogs, fishes, leeches), fruit, eggs, confectionery, cloth, balls, etc.; hard—stones, rings, coins, buttons, thimbles, keys, padlocks, pieces of wood, metal, leather, etc.

3. Unclassified bodies: feathers, ears of grain, leaves, blades of grass, etc.

Etiology.—Hurry and voracious eating, in many cases, are the means of lodging bones and large masses of food in the œsophagus, and these make up the larger number of the cases. Accident accounts for the swallowing of many of the smaller objects, which may be held in the mouth for convenience in use or from careless habits. Infants and imbeciles are often the victims of a propensity to put all sorts of articles in their mouths. The inability of the one class to tell the origin of the trouble, and the habitual mendacity or incompetence of the other, may render diagnosis quite difficult, and, indeed, often impossible during life. Jugglers and those who emulate their feats may be caught in trying to swallow very large objects. Persons in fear of thieves, and criminals in fear of detection, have been known to attempt swallowing, for concealment, such objects as large coins, rouleaux of coin, jewellery, etc., and impaction has then resulted. In sleep or unconscious conditions accidents may happen by the swallowing of large or sharp bodies, especially false teeth or palate-obturators. A curious story is told on the authority of Mackenzie, quoting v. Langenbeck. A syphilitic patient was wakened from sleep by being choked by her own nose which had fallen into the gullet, the bony framework having been detached by necrosis. Leeches, live fish, mice, serpents, and lizards have all been known to produce serious symptoms by their sticking in the œsophagus. They enter by the folly of individuals who, in hope of a fee or from bravado, swallow them; or are sucked up from pools or streams by careless or thirsty people. Large masses of food or round-worms have been regurgitated from the stomach and have become lodged in the gullet. The latter accident occurred in the practice of a personal friend of the writer. A lady had been suffering for some time from vague symptoms of intestinal dyspepsia, and had been under his care. He was called suddenly and found the lady cyanosed and unconscious. On examining the pharynx with his finger he extracted a lumbricoid of huge size, which was impacted opposite the cricoid cartilage. Occasionally portions of apparatus used in exploring the œsophagus become detached and impacted. This has happened with the sponge of a probang, with the metallic end of Graefe's coin-catcher, and with other instruments. Strictures and diverticula offer special advantages for the lodgement of foreign bodies, which are often to be found in them.

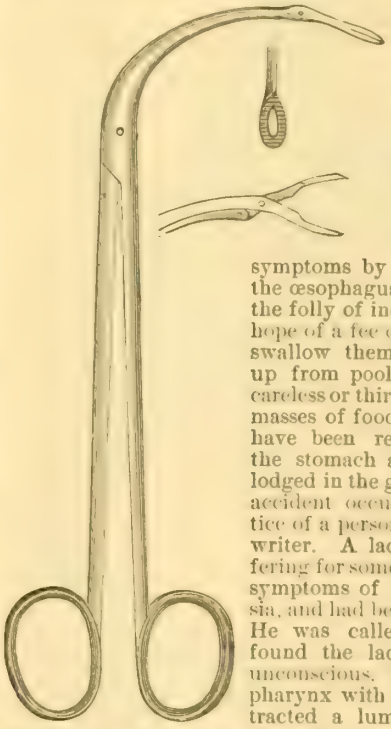
Fig. 2534.—Œsophageal Forceps.

Site.—Irregular and pointed bodies are often arrested in the pharynx or opposite the cricoid cartilage. Large boluses may be arrested at the same point. The other favorite sites are the root of the neck, at the diaphragm, and at the cardia. Bodies may be moved from one position to another in consequence of efforts at expulsion by swallowing or vomiting. Small pointed objects may stick at any level.

The symptoms are usually quite distinct, particularly when the foreign substance is impacted in the upper portion of the canal. Dysphagia is usual, but may pass off as soon as a degree of tolerance is acquired. Pain is very variable in intensity and character. If the bodies

be sharp there may be acute pain and localized tenderness, while with a large, smooth body the pain will be of an ill-defined, stretching character and not distinctly localized. Especially when the impaction is in the upper portion of the canal there is apt to be laryngeal dyspnœa from reflex spasm or from direct pressure. The asphyxia from this source may become very intense; indeed, in a few cases has been fatal. This dyspnœa is apt to excite intense terror in the patient, and he will wander restlessly about until relieved. The voice will be altered in quality, usually becoming stridulous or metallic in character. Cough, too, is often excited, and is of a harsh, dry character. If the cough remain long there will be mucous expectoration, which may be tinged with blood. Œsophagismus may occur, and in children, less often in adults, general convulsions. A swelling in the neck may occasionally be felt after the impaction of a large mass. The primary symptoms may persist for some time, and are apt to be increased by œsophageal inflammation or ulceration. Perforation of the coats of the organ and peri-œsophagitis may thus result, or we may have perforation of a neighboring organ, as the trachea, a blood-vessel, the pleura or pericardium. A small pointed body may migrate to a considerable distance after penetrating the gullet without exciting noticeable inflammation.

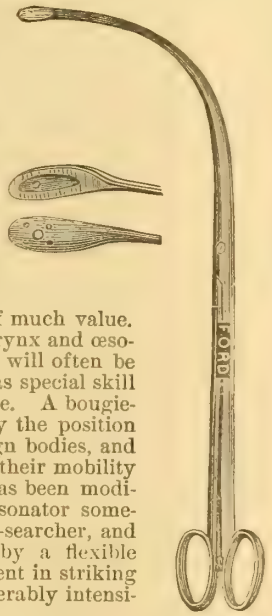

Fig. 2535.—Œsophageal Forceps.

Physical examination furnishes in some cases the crucial test. The laryngeal mirror may give some information, if the body is at the entrance of the gullet. There are various special mirrors which have been devised for examination of the œsophagus, but in general the œsophagoscope has not proved of much value. The examination of the pharynx and œsophageal orifice by the touch will often be of more service, unless one has special skill in the use of the laryngoscope. A bougie-à-boule will define accurately the position and presence of some foreign bodies, and will furnish some ideas as to their mobility and size. This instrument has been modified by the addition of a resonator somewhat like that of the stone-searcher, and when conveyed to the ear by a flexible tube the click of the instrument in striking a hard body will be considerably intensified.

Auscultation may add some slight information, but is not of great value. In the case of metallic bodies the delicate galvanometer used in locating bullets and the like might be tried.

Prognosis.—This varies with the nature of the body and its location. Large irregular bodies offer a much more serious obstacle than smooth or smaller bodies. When foreign bodies have been impacted for a considerable time, and when there is a gradual onset of symptoms pointing to ulceration, the prognosis is unpromising. Still, if the body is smooth and of regular outline a certain tolerance may be acquired, and it may remain in the œsophageal wall for years without giving rise to severe symptoms; or it may remain encysted outside, after ulcerating through the coats of the organ. Stricture may follow the impaction, cicatricial contraction being produced by violence or ulceration even though the body be removed. No rule for the prognosis can be given. Each case must be judged on its own merits. Delay is dangerous, as there is a probability that the surgeon will in most cases give relief, and waiting for the *vis medicatrix naturæ* will seldom lead to recovery.

Treatment.—Extraction is the aim of the surgeon. This may be accomplished by operating through the mouth or by external œsophagotomy; or the body may be pushed on into the stomach and, if necessary, extracted by gastrotomy. Anæsthesia should generally precede efforts at extraction. If the nature of the object is such as to render extraction by the mouth at all probable, the attempt should be persevered in. For this purpose, if the object be high and can be readily detected, some of the various œsophageal forceps may be used. Figs. 2533, 2534, and 2535 show some of the simpler forms of these forceps, of which many have been devised. The complicated forceps are not serviceable. In using the forceps the finger should serve as a guide, and only slight force should be used lest the mucous membrane be torn by the instruments.

If the body cannot be caught by the forceps and is suited by its shape to the coin-catcher (Fig. 2536), this instrument may be used. It should be employed with caution, and at the same time the effort should be persistent. Pass the hook beyond the foreign body, and by gently withdrawing the instrument try to bring with it the foreign body. It has happened that the instrument itself has been caught, and has been freed only by the exertion of considerable force or of an enviable outlay of patience; even œsophagotomy has been required to relieve this condition.

Fig. 2536.—Money-catcher and Sponge-probang.

Light and small bodies—fish-bones, pins, etc.—may best be caught by the bristle- or umbrella-probang (Fig. 2537), an instrument so constructed that it may be introduced beyond the foreign body, and an arrangement of bristles expanded so as to resemble a chimney-sweep's broom. This ingenious instrument is often successful with small foreign bodies.

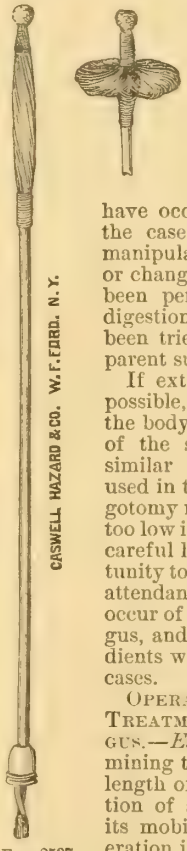

Fig. 2537.—The Bristle- or Umbrella-probang.

Inversion and the administration of emetics are not generally advisable, but have occasionally been of use. In the case of large bodies external manipulation has so moulded them or changed their axis that they have been permitted to pass. Artificial digestion of food-masses *in situ* has been tried, and sometimes with apparent success.

If extraction by the mouth is impossible, we may attempt to force the body into the stomach by the use of the sponge-probang (Fig. 2536) or some similar instrument. Little force should be used in this manipulation. External œsophagotomy may be practised when the body is not too low in the gullet, and it promises success in careful hands. No field offers greater opportunity to develop the resources of the medical attendant than some of the special cases which occur of impacted foreign body in the œsophagus, and there are very many ingenious expedients which have given success in desperate cases.

Operations for the Diagnosis and Treatment of Diseases of the Œsophagus.—*Exploration by bougies* is useful in determining the presence, site, calibre, nature, and length of a stricture and the reality and position of a foreign body, with some ideas as to its mobility, size, and shape. The same operation is used for the treatment of strictures by dilatation, for forced feeding in cases of aphagia from various causes, and for the treatment of certain stomach-affections.

The instruments used are bougies of gum-elastic, or material of similar consistence, feeding-tubes of soft rubber, or bougies-à-boule, which have usually a

sleeder whalebone or vulcanized rubber stem and interchangeable tips of various diameters (see Fig. 2538)

Fig. 2538.—Œsophageal Bougies, Olivary, Round, and Conical Ends.

The instrument makers furnish a wide range of choice in the form and material of the bougies. They may be conical, simply rounded, or more or less olivary at the end. In size they vary from quite small, less than an ordinary lead-pencil, to bougies of the size of the index finger. No system of numbering the instruments is sufficiently general to enable one to follow it in describing them.

The bougies à boule (Fig. 2539) are of various shapes, depending upon the preferences of the designers. Mackenzie uses an instrument somewhat flattened from behind forward, others like the simple oval or olivary bougie, and still others prefer a conical point and an acorn-shaped outline. These instruments are said to be easier of introduction than any other form, as the irritation is less when only a portion of the œsophagus is distended, and the shape of the end, moreover, partakes of that of the natural food-bolus.

Anæsthesia is desirable, at least when a thorough examination is to be attempted, or until the œsophagus has become to a certain extent habituated to the instrumentation. Before introducing an instrument it is well to warm it, and then to thoroughly smear it with vaseline. The tongue should then be pressed slightly downward and forward by the index-finger of the left hand and the bougie guided by the finger to the œsophageal opening. In some cases it will be necessary to use a mouth-gag of some kind to hold the mouth open and to prevent the patient from injuring the operator by biting him. If the median line be kept, there will usually be no difficulty in passing the instrument, though some advise that it be directed to the left, as the œsophagus lies a little to that side in its upper part and there is less danger of injuring the glottis. It is not usually necessary to extend the head, as the natural position will commonly be just as favorable. The examination often excites vomiting, and it is well to be prepared for it by having the patient's clothing protected and by having a basin at hand. A little practice will enable the patient to take the instrument without much inconvenience, and even to aid its passage by efforts at deglutition.

Fig. 2539.—Olivary Œsophageal Bougie.

In adults the distance from the teeth to the cricoid cartilage is about six inches and the length of the œsophagus about ten inches, making the distance from the teeth to the stomach about sixteen inches.

The utmost gentleness must be used, and if resistance is met with it is well to start afresh. In case of suspected stenosis from any cause always begin the examination with a large instrument and select smaller sizes until one is found that will pass. This may be left in place for a few minutes and afterward be replaced by a larger instrument, or the session may be resumed at another time. Do not attempt too much at one time. Patient persistence is sometimes demanded; in some cases weeks have been consumed before the smallest instrument passed a stricture which has finally been successfully dilated. In case of spasm do not force the instrument but hold it gently against the stricture and the resistance will gradually melt away. Foreign bodies which it is desirable to push on to the stomach must be assisted in their progress rather than forced.

In passing the small soft tube through the nose the same method is followed, but it must be swallowed by the patient, as its structure is not firm enough to allow it to be pushed from behind. The end should be secured, lest the tube be swallowed.

Internal œsophagotomy is an operation devised for the relief of stricture, especially of cicatricial origin, which is not amenable to treatment by dilatation. The operation may be briefly described as the division of a stricture by a cutting instrument (the œsophagotome) passed through the mouth.

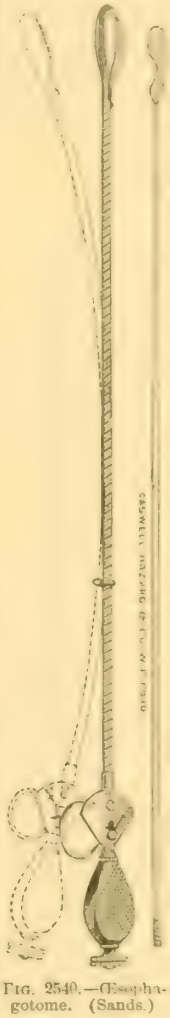

Fig. 2540.—Œsophagotome. (Sands.)

There are various instruments which have been invented for the purpose, and most of them are arranged to cut from below upward. That devised by Dr. Sands, of New York, is shown in the cut (Fig. 2540), and will serve as a type of its kind. It consists of a flexible stem of spiral metal, at the end of which is a bulb of moderate size. The blade is concealed in the enlargement, but may be advanced by means of a screw in the handle. The degree to which the blade is protruded is detected by the movement of an indicator over a dial at the handle. The bulb is passed beyond the stricture, the blade protruded as far as is deemed safe, and the instrument withdrawn until the strictured part is passed. There are instruments devised for cutting from above downward (especially Maisonneuve's), but their use has been strongly condemned as being extremely dangerous and uncertain. The operation may require repetition before a cure is effected: in one case seven operations were done, with ultimate recovery. A few days after the operation, bougies should be used to prevent recontraction. The mortality after operation is one-third of all the cases (Gross), death resulting six times in eighteen cases directly from the operation. While the operation is dangerous, it has the advantage of reaching certain cases of annular stricture which cannot be dilated on account of their resilience, and, furthermore, of leaving no deforming external scar.

External Œsophagotomy.—This operation is practised for the relief of stricture and for the removal of foreign bodies. When done with the intention of making a permanent fistula for the introduction of food, the operation is known as œsophagostomy. The patient should lie with the head and shoulders elevated, and the head extended and turned toward the right side.

The skin-incision is about the same as that for the ligation of the left common carotid artery, commencing at inch or an inch and a half above the left sterno-clavicular articulation, and extended for about three inches upward along the anterior border of the sterno-cleido-mastoid muscle. It should not reach a higher level than the upper border of the thyroid cartilage, nor pass lower than an inch above the clavicle. The sheaths of the great vessels of the neck should be exposed and drawn to the outer side with the sterno-mastoid muscle. The anterior belly of the omo-hyoid muscle may be drawn aside or may be divided. The sterno-hyoid and sterno-thyroid muscles may be drawn to the inner side with the larynx

and thyroid body. Care should be taken to avoid the trunk of the superior thyroid artery, which should lie above and to the inner side of the incision. A sound should now be passed into the œsophagus in order to define its position, unless it is already made distinct by a foreign body. The deep dissection should be made with the fingers and forceps, by tearing. The recurrent laryngeal nerve, which lies upon the œsophagus, must be avoided. Hæmorrhage should be very carefully checked during the operation, for the wound will be deep and blood will obscure the parts. When the œsophagus is reached a small vertical opening is to be made and enlarged by stretching as much as is needed. If the operation is done for the removal of a foreign body, the extraction should be accomplished as gently as possible; if for stricture, the latter is to be divided. It has not been found useful to sew the wound in the œsophagus, but no harm will follow the insertion of a few absorbable stitches. The external wound should, however, not be closed, as the wound in the gullet will favor sepsis and the loose cellular planes in the neck will facilitate dangerous infiltration of pus.

If a permanent fistula is desired (œsophagostomy) the œsophageal wall should be attached to the skin loosely by two or three stitches of silk. The results of the operation are, it must be confessed, somewhat uncertain. For stricture it has been fatal in about four-fifths of the cases, and the duration of life has been less than a month in the cases of recovery (Gross). For foreign bodies the operation is somewhat more successful, though it is to be feared that the contraction of the scar from so large a wound healing by granulation would produce very disastrous results.

Other Operations.—Gastrostomy for purposes of artificial feeding has its history in connection with stenosis of the œsophagus, and is to be preferred as being an easier operation and as prolonging life somewhat more than the fistula in the neck (see article Gastrectomy).

Gastrotomy has been done, and a stricture at or near the cardia treated by rapid divulsion, by Loreta, of Bologna, in three cases with no deaths. What has been the permanent outcome of the operation as regards the stricture cannot be stated.

Extirpation of cancer of the gullet with resection of the walls of the organ (œsophagectomy), has been accomplished in a few cases, but it would seem to be an operation which has to be more thoroughly tested before its value can be estimated. *F. A. Manning.*

[1] V. Ammon, Berlin, 1842, Die angeborene chirurg. Krankheiten des Menschen, etc.; Tab. viii., figs. 10-16, shows a number of these forms of congenital deformity.

[2] Mackenzie: Manual of Diseases of the Throat and Nose, etc., vol. ii., p. 89. New York, Wm. Wood & Co., 1884.

[3] Luschka: Virchow's Archiv f. Path.-Anatomie, etc., 1858, Bd. 42, p. 473 et seq.

[4] Billroth u. Luecke: Deutsche Chirurgie, Lief. 35. Koenig: Krankh. des . . . Œsophagus, pp. 84 and 86, Stuttgart, 1880.

[5] Cyclopædia of the Pract. of Med., Am. transl., vol. viii., p. 18.

[6] Krishaber: Trans. International Med. Cong., Lond., 1881, vol. ii., p. 302.

[7] Am. Jour. Med. Sci., 1884, vol. i., p. 58 et seq.

[8] Koenig: Deutsche Chirurg., Lief. 35, p. 95. For a more complete list and elaborate classification of foreign bodies in the œsophagus, see Poulet: Foreign Bodies in Surgery (transl.), Wood's Library of Standard Med. Authors, vol. i., p. 71.

ŒSTRUS (from the Greek *οἶστρος*, gadfly) is a genus of dipterous insects (the order *Diptera* contains the fly, mosquito, and other insects with two wings), which is parasitic in various animals and sometimes in man.

Œstri or their larvæ (called maggots or bots) have been found in the intestines, under the skin, in the nose, ears, open sores, etc., of man.

In horses the fly (*Gastrophilus equi*) lays its eggs on the hair about the breast and legs, where the animal can lick them off; in his stomach they are hatched, and the larva clings to the mucous membrane and undergoes further development; finally, after six or eight months, it floats along with the intestinal tide to the anus, is discharged, buries itself in the ground, and after six or seven weeks it develops into a fly ready for active service. The maggots or "bots" are said rarely to cause damage to the horse, and medicine, unless strong enough to injure the horse, will not always expel them. Turpentine is, however, recommended as often effectual.

Another gadfly leaves its eggs in the nostrils of the sheep. The larva of a gadfly found at Cayenne is called "macaco worm;" it usually attacks the skin of oxen and dogs, but sometimes is found in man.

Various cases are reported of larvæ or maggots being found in the nostrils or other openings of man.

It is almost exclusively the maggots or larvæ that are met with in medical practice, and these come from quite a variety of insects, both of *Œstrus* and of other genera. The determination of the genus to which the larvæ belong requires the knowledge and experience of a skilled entomologist.

According to Dr. C. M. Harrison (*New York Medical Record*, vol. xxviii., p. 399), in Texas "there are two species of flies which attack diseased parts, viz., the blue-bottle (*Musca vomitoria*) and the flesh-fly (*Sarcophaga carnaria* Meig). The blue-bottle deposits eggs, which are hatched in two or three hours, provided they are kept moist and warm; and the flesh-fly deposits living larvæ, which commence to burrow at once. It was of the latter [former ?] kind that Linnæus said that the larvæ of three females would devour the carcass of a horse as quickly as would a lion. These are popularly known as 'screw-worms,' and they increase in size with amazing rapidity."

One female flesh-fly will produce about twenty thousand young, and these will increase about two hundredfold in weight in twenty-four hours.

The writer has removed many maggots from the nose and from ears affected with purulent inflammation. In these positions they sometimes induce great pain and adhere very tenaciously. Their removal is facilitated by subjecting them to the action of chloroform vapor; after being anæsthetized they may be removed by syringing with warm water.

Among the flies, the maggots of which are most commonly noticed in man, are *Musca domestica, M. carnaria, M. larvorum, M. nigra, M. cibaria, M. stabulans*, and *M. cæsar* (the latter affecting sheep more especially).

Chas. E. Hackley.

OEYNHAUSEN, formerly called Rehme, in Westphalia, Prussia, is a thermal station of some repute. The hot springs are three in number. The waters contain from 32 to 41 parts per 1,000 of solid constituents, of which from 24 to 31 parts are of sodium chloride. The temperature varies from 27.3° to 31.6° C. (81° to 88° F.). There are also two salt springs containing respectively three and nine per cent. of sodium chloride. Finally there is a bitter water, which is occasionally employed for internal use. This spa is frequented by nervous, scrofulous, and anæmic individuals; by those suffering from chronic articular, or muscular rheumatism, diseases of the female organs of generation, locomotor ataxia, tubercular bone and joint affections, and also by those convalescing from typhoid fever or other debilitating disease. The season extends from the middle of May to the end of September. *T. L. S.*

OFEN, or Buda, is that part of the capital city of Hungary, Budapest, which lies on the right bank of the Danube River. It contains a number of thermal springs, rather weak in mineral constituents, of a temperature varying from 45° to 63.5° C. (113° to 146° F.). Among the most important of these springs are the Königsbad, Kaiserbad, Blocksbad, Raizenbad, Bruckbad, and Wäscherbrunnen.

The waters are employed chiefly for bathing, though occasionally taken internally. Baths are given in the treatment of chronic articular, and muscular rheumatism, stiff joints following sprains and fractures, gouty affections, and chronic skin diseases. In some uterine affections, more particularly ulcerative conditions of the os uteri, general baths are used in conjunction with vaginal douches. Internally, the waters are sometimes prescribed for chronic catarrhal conditions of the stomach, intestines, and urinary bladder, nephritis, especially

gouty kidney, and chronic enlargements of the liver and spleen

The following is the composition of two of the springs, according to the analyses of Molnár, calculated in grammes per litre:

	Kossuth.	Bercsényi
Potassium sulphate	0.142925	0.061969
Sodium sulphate	0.145262	0.268598
Calcium carbonate	0.057788	0.434548
Sodium chloride	0.311110	
Sodium carbonate	0.050142	0.264416
Magnesium carbonate	0.142955	0.051194
Sodium phosphate	0.017695	0.014882
Calcium phosphate	0.004124	0.004058
Aluminium phosphate	0.005642	0.013888
Lithium phosphate		0.002921
Ferrous carbonate	0.002701	0.015588
Calcium carbonate	0.288261	0.597408
Lithium carbonate	0.005395	
Magnesium carbonate		0.165983
Silica	0.001736	0.020416
Organic matters, etc.	0.053808	0.040633
Total solids	0.976265	1.565365

On an island in the Danube, Margaretheninsel, are a number of artesian wells, the waters of which are used externally and internally in the treatment of many of the affections mentioned above, and also of osteitis, and the secondary manifestations of syphilis. The most important constituents of the waters are calcium carbonate, sodium chloride, calcium sulphate, and magnesium carbonate. There is a large amount of free carbonic acid gas. The temperature of the springs is 45° C. (113° F.). The bathing establishment on the Margaretheninsel, is said to be one of the finest of its kind in Europe.

In addition to these thermal springs there are a number of athermal bitter waters at Buda, the best known and most extensively used of which is the Hunyadi-János. For the composition of this water and the therapeutic indications of the group, see article Hunyadi-János, vol. iii., p. 724 of this HANDBOOK.

The season at Buda extends from the first of May to the end of September, though the baths are taken in winter also. A course of treatment lasts the usual time of three weeks to a month. *T. L. S.*

OINTMENT. Under this designation are usually included all those substances of a fatty consistency, whether composed of fat or not, which are employed in medicine as a coating to the diseased integument or as a means of introducing medicinal substances into the economy by way of the skin.

The softer preparations are sometimes called pomades, while those of a firmer consistency are known as cerates; but the various forms are usually included under the middle term "ointment."

Ointments usually contain lard as a basis, but marrow, suet, and mixtures of oils with paraffin or wax, are often employed. Some years ago the preparations known as cosinoline and vaseline, derivatives of coal-tar, were introduced into use as bases for ointments, and they have found their way into general employment, and are at present designated by the expression petrolatum in the U. S. Pharmacopœia. More recently a substance has been brought forward known as lanolin, derived from the wool of sheep, in which the fatty acids are found in combination with cholesterin instead of glycerin, as is the case with the fats and oils in ordinary use.

Under the general designation of ointments may also be included certain pastes or similar mixtures of an ointment-like consistence and made up of kaolin and linseed oil.

Ointments are employed with three principal objects: 1, To cover and protect abraded and inflamed areas; 2, to act as stimulants to the cutaneous surface; 3, as a means of conveying medicine to the general economy. To meet the first indication it is requisite that the base of the ointment should itself be bland and unirritating. Hence, if fats are employed, these should be carefully selected and should be as carefully preserved from decomposition. In many cases fats of any kind are badly borne by the skin, and here the petrolatum base may often be made use of alone or in combination with starch. The stimulant effect of ointments is obtained by the addition of some ingredient, vegetable or mineral, of which this effect is desired. Most compound ointments belong to this class, and the skill and conscience of the pharmaceutist are tried to the utmost in their preparation. When a superficial effect is desired, any ointment base will be sufficient, but where the medicinal influence is to penetrate deeper, the choice of a base is a matter of some importance. After a very extensive experience with all the bases hitherto brought forward, including those whose "penetrative" qualities have been most loudly trumpeted, the writer is of opinion that the true fats, of which lard is an example, are best calculated to carry medicinal substances into the system.

The systemic effects of medicines introduced through the skin by means of ointments is decided only in a few cases, of which mercury is a conspicuous example. Belladonna and other drugs also act vigorously in immediate proximity to the place of inunction, but with somewhat less intensity upon the system at large. In this use of ointments, even more than in their employment with the view to their local effect, the base of the ointment is by no means a matter of indifference. The kaolin pastes have little or no penetrative power, vaseline a less decided value in this respect than lard, and the latter, it is said, less than lanolin. With regard to this point, the writer has just stated his own opinion, but it must be said that the views of various observers differ. Fox and Blanc think that lanolin is more readily absorbed by the skin than any other fatty substance, and is useful as a basis for ointments when an effect upon the deeper skin or upon the whole system is desired. On the other hand, Ritter, as the result of a series of careful experiments, cannot admit that lanolin has any advantage over other ointments in facilitating the passage of chemical matters through the skin.

The following are examples of the various kinds of ointments ordinarily employed in medicine:

SOOTHING.—*Unguentum Diachylon:* ℞. Olei olivæ opt., Gm. 480 (℥ xv.); pulv. litharg., Gm. 120 (℥ iij. ʒ vj.); aquæ, q.s. Coque. Fiat unguent.

Ung. McCall Anderson: ℞. Bismuthi oxidi, Gm. 4 (ʒ j.); acidi olcici, Gm. 32 (℥ j.); ceræ albæ, Gm. 12 (℥ iij.); vaselini, Gm. 36 (ʒ ix.); ol. rosæ, q.s. M.

STIMULANT.—*Whitfield's Ointment:* ℞. Olei cadini, flor. sulphuris, āā. Gm. 12 (ʒ iij.); saponis viridis, adipis, āā. Gm. 24 (ʒ vj.); cretæ pulv., Gm. 8 (gr. xxv.). M. Fiat unguent.

Ammoniated Mercurial Ointment: ℞. Pulv. hydrarg. ammoniat., Gm. 1.5 (℈ j.); seri benzoinati, Gm. 9.5 (ʒ ij. ℈ j.); adipis, Gm. 2 (ʒ ss.); olei amygdalæ dulcis, Ʒ ss., vaselini, ad Gm. 24 (℥ vj.). M.

MEDICATED OINTMENTS employed for systemic effects.—*Ung. Hydrargyri*, U. S. Ph.; *Ung. Iodi*., *Ung. Belladonna*, U. S. Ph. (For further information upon this subject the reader is referred to the article on Inunction in this work.) *Arthur Van Harlingen.*

OJO CALIENTE. *Location and Post-office*, Ojo Caliente, Rio Arriba County, New Mexico.

ACCESS.—By Espanola Branch of the Denver & Rio Grande Railway to Barranca, thence twelve miles by stage to springs.

ANALYSIS (Professor O. C. Marsh).—One pint contains:

	Grains.
Carbonate of soda	11.410
Carbonate of lithia	0.158
Carbonate of iron	0.227
Carbonate of lime	0.353
Carbonate of magnesia	0.215
Chloride of sodium	2.772
Sulphate of potassa	0.576
Sulphate of soda	0.291
Silica	0.153
Total	16.945

Temperature, 122° F.

THERAPEUTIC PROPERTIES.—The temperature and alkaline ingredients render these waters valuable reme-

dies in the treatment of rheumatism, gout, and catarrhal affections.

These springs are situated in the northeastern part of New Mexico. They were known to the Indians, and later the Spaniards visited them. With the building of the Denver & Rio Grande Railway they have become the resort for the people of all sections. The springs are at an elevation of 6,000 feet above sea-level, and have a flow of 1,000 gallons per minute. *George B. Fowler.*

OLD POINT COMFORT AND NEWPORT NEWS.

[For a detailed explanation of Table A, one of the charts obtained from the U. S. Chief Signal Office expressly for this HANDBOOK, and for suggestions as to the best method of using this, and other like charts, see "Climate"].

Old Point Comfort, Va., the south-eastern extremity of Yorktown Peninsula, is a point lying on the northern side of the mouth of the bay of Hampton Roads, where the latter expands into the great gulf known as Chesapeake Bay. Hampton Roads may be regarded either as an expansion of the James River near its mouth or as the lower portion of a branch of Chesapeake Bay, which branch, under the name of the James River, extends inland, in W.N.W. direction, for a distance of about forty miles. The mean width of Hampton Roads is about

TABLE A.

Climate of Norfolk, Va.—Latitude 36° 51′, *Longitude* 76° 17′.—*Period of Observations, January* 1, 1871, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 13 *feet.*

	A			AA	B		C	D	DD	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Mean daily range of temp. deduced from Columns C and D.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	39.0	44.1	39.5	40.8	49.2	34.4	47.5	32.7	14.8	80.0	54.0	31.0	8.0	30	29
February...	39.3	47.8	41.6	42.9	48.7	37.4	53.2	37.1	16.1	81.0	64.0	30.0	9.0	24	19
March	44.2	53.2	46.7	48.0	55.1	41.1	55.7	40.8	16.9	81.0	67.0	38.0	16.0	23	22
April	53.2	62.1	53.7	56.3	62.5	52.3	64.0	47.5	17.5	92.0	80.0	45.0	27.0	23	21
May.....	64.3	72.6	64.6	67.1	73.3	63.0	75.9	58.1	17.8	98.0	88.5	54.0	38.0	24	25
June	74.0	81.6	71.5	75.7	78.9	71.8	84.2	65.7	18.5	102.0	92.0	64.0	53.0	20	19
July.....	78.2	85.2	75.5	79.6	82.2	76.8	89.0	70.9	18.1	102.5	95.0	71.0	60.0	18	22
August....	75.4	82.0	73.9	77.1	79.5	73.3	84.7	69.7	15.0	99.0	91.0	69.0	58.0	19	20
September..	68.2	75.8	68.2	70.7	77.5	67.5	79.1	65.3	13.8	96.0	82.0	64.0	50.5	28	16
October	57.7	66.2	59.1	61.0	66.8	56.2	70.9	56.4	14.5	89.0	77.0	48.0	31.0	21	23
November..	46.6	53.9	48.4	49.6	55.0	46.0	58.7	43.8	14.9	80.0	64.0	34.0	20.0	20	19
December..	39.1	46.2	41.4	42.2	50.0	33.2	50.9	36.7	14.2	73.0	57.0	27.0	6.0	25	24
Spring	.....	.....	.....	57.1	61.6	55.0	....	....	17.4	.....	.....	.....	.....	.....	.....
Summer....	.....	.....	.....	77.4	79.7	76.2	....	....	17.2	.....	.....	.....	.....	.....	.....
Autumn....	.....	.....	.....	60.4	66.4	58.0	....	....	14.4	.....	.....	.....	.....	.....	.....
Winter	.....	.....	.....	41.9	49.1	36.6	....	....	15.0	.....	.....	.....	.....	.....	.....
Year	.....	.....	.....	59.2	60.6	57.6	....	....	16.0	.....	.....	.....	.....	.....	.....

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	Miles.
January....	72.0	75.5	11.2	8.8	20.0	3.89	N.	7.5
February...	72.0	70.6	10.9	8.6	19.5	3.85	N.E.	8.7
March.....	65.0	66.4	10.8	10.0	20.8	4.35	N.	9.5
April	65.0	68.2	10.5	9.5	20.0	4.29	S.W.	8.9
May	60.0	68.8	12.3	11.0	23.3	3.54	S.W.	8.0
June	49.0	69.6	12.9	9.5	22.4	4.15	S.W.	7.4
July.....	42.5	70.3	14.5	8.5	23.0	5.39	S.W.	6.7
August.....	41.0	75.6	13.5	9.1	22.6	6.11	S.W.	6.4
September..	45.5	76.9	10.4	10.6	21.0	5.23	N.E.	6.6
October	58.0	74.7	9.6	13.7	23.3	3.96	N.E.	7.2
November..	60.0	72.7	9.8	11.2	21.0	3.58	N.	7.7
December..	67.0	71.8	11.8	10.1	21.9	3.80	S.W.	7.5
Spring	82.0	67.8	33.6	30.5	64.1	12.18	S.W.	8.8
Summer....	49.5	71.8	40.9	27.1	68.0	15.65	S.W.	6.8
Autumn....	76.0	74.8	29.8	35.5	65.3	12.77	N.E.	7.2
Winter	75.0	72.6	33.9	27.5	61.4	11.54	N.	7.9
Year	96.5	71.8	138.2	120.6	258.8	52.14	S.W.	7.7

four and one-half miles; from point to point across its mouth it is two and one-half miles wide. The James River opens into Chesapeake Bay at the southern extremity of the latter, and directly opposite its opening into the Atlantic Ocean; so that Old Point Comfort commands a view straight out to sea in an easterly direction between Cape Charles and Cape Henry. The mouth of Chesapeake Bay between these two capes is twelve miles wide; an imaginary line drawn from cape to cape would lie twenty miles distant from Old Point Comfort.

Into the bay of Hampton Roads, at a short distance within its mouth, and upon its southern shore, almost directly opposite Old Point Comfort, opens the Elizabeth River, and on this river, at a distance of some four or five miles from its point of opening into Hampton Roads, stands the city of Norfolk, Va. The course of the Elizabeth River being nearly due north and south, Norfolk lies necessarily almost due south of Old Point Comfort. The distance between the two places, measured in a straight line, is eleven miles. All vessels coming down the James River from Richmond and Petersburg, and those entering and leaving the harbor of Norfolk (and the Portsmouth Navy Yard there situated), must pass close to Old Point Comfort, while the entire sea-going commerce of Chesapeake Bay passes it at no great distance on its way to and from the ports of Baltimore, Annapolis, and Alexandria.

When we consider the important position of Old Point Comfort from a strategic point of view, we are not surprised that it should have been chosen as the site of one of the chief sea-coast fortifications of the United States—Fortress Monroe. When we consider the attractions as a place of seaside resort of a point commanding so wide a marine view, and where the constant presence of many moving craft gives an especial element of life and interest to such a view, we are not surprised to learn that "Old Point" has been chosen as the site of one of the most popular seaside "watering places" of the country. The large hotel, standing directly upon the beach, and the fortress, are but three hundred feet distant one from the

TABLE B.

Temperatures and Rain-fall at Fortress Monroe, Va., Latitude 37 North. Longitude 76 19 West. Elevation above Sea-level 8 feet. ("Smithsonian Contributions to Knowledge," Nos. 277 and 222).

		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year
Mean Temperature[*]	Jan. 1825 to Dec. 1879	42.41	41.81	49.99	58.99	68.13	74.62	78.78	77.86	72.44	61.90	51.41	41.10	57.54	77.07	61.92	41.77	59.32
Max. Temperature[*]	Jan. 1826 to June 1854	72.00	72.00	78.00	91.00	91.00	95.00	102.00	98.00	96.00	84.00	82.00	69.00	...	...	...	...	...
Min. Temperature[*]	... ...	2.00	1.00	15.00	31.00	45.00	50.00	61.00	60.00	49.00	30.00	15.00	17.00	...	...	...	...	...
Mean Daily Range of Temperature	Jan. 1826 to Dec. 1879, inclusive																	
Rain-fall (Inches)	Including the Years 1851, 1852, 1853, 1854.	3.37	2.72	3.30	2.98	3.89	4.32	5.34	5.66	4.65	2.92	3.31	4.58	10.17	15.32	10.88	10.67	47.04

[*] Means derived from observations at 7 A.M., 2 P.M., and 9 P.M., by formula $\frac{7\text{ A.M.} + 2\text{ P.M.} + 9\text{ P.M.}}{3}$.

[†] Not derived from observations made with maximum and minimum thermometers, but given as recorded at regular hours of observation.

other. A pretty constant exchange of visits between the inmates of the fort and those of the hotel is a characteristic element in the life at "Old Point," and unquestionably has operated to make the place popular. Music (by the military band) and dancing are a prominent feature in the hotel life, and this is a matter which should not be disregarded in weighing the value of the place from a sanatory point of view. The hotel accommodations at the only hotel now existing at "Old Point" are excellent. According to Appleton's "Handbook of Winter Resorts" (1886-87), this hotel accommodates one thousand persons. In the spring season (February, March, and April), the securing of good rooms is difficult, as the house is very crowded.

At Newport News, seven miles W.S.W. of "Old Point," a hotel accommodating three hundred persons has recently been built; and here, too, the character of the accommodations is said to be excellent. At this hotel the "provisions for the amusement of guests are supplied in buildings entirely separate from the hotel proper" (Appleton's "Handbook"); and, partly on this account, still more on account of its greater distance from Fortress Monroe, there is doubtless a far greater degree of quiet attainable than is the case in the hotel at "Old Point." The marine view at Newport News is less extensive than at "Old Point;" for the latter, standing at the gateway of Hampton Roads, looks straight out to sea through the wider gateway of Chesapeake Bay; while Newport News stands six and one-half miles inside the entrance of Hampton Roads, and it will be remembered that the width of this entrance is but two and one-half miles. The hotels at both points are open throughout the year, and, since the establishment of rapid communication between Norfolk and New York City by the Cape Charles route, are readily accessible to visitors from the Northeastern States. The bathing at both places is excellent during the summer months. Good facilities also exist for fishing and sailing excursions. Visits to the Portsmouth Navy Yard, to the National Soldiers' Home, to the Normal and Agricultural Schools at Hampton, and to the National Cemetery, add interest to a sojourn at both of these neighboring resorts. Dr. F. C. Shattuck, writing on Old Point Comfort in the *Boston Medical and Surgical Journal* (April 6, 1882), alludes to a good shell road extending from Old Point Comfort to the town of Hampton, a distance of about three miles, and also tells us that "at low tide one can drive over the beach, which is said to extend for fifteen miles toward the Chesapeake." He very justly calls attention, moreover, to the great advantage of the beach as a play-ground for children.

The climates of Newport News and of Old Point Comfort are, of course, very nearly identical, if not precisely similar one to the other; both places being seaside re-

TABLE C.

Showing the Average number of Days in the Years 1877, 1879, *and* 1880 *on which certain Maximum Temperatures were recorded in each of the three Months specified. Also the actual number of Days throughout the three Seasons (a total of* 9 *Months, or* 268 *Days) on which such Maximum Temperatures were Observed.*

		February.			March.			April.			Season.		
		Norfolk.	New York.*	Boston.	Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.	Norfolk.	New York.*	Boston.
Warm	85° +	....	....	....	....	....	....	0.33	....	....	1	....	....
	80°-84°	....	....	....	0.33	....	....	3.66	0.33	....	12	1	....
	75°-79°	0.66	....	....	1.00	....	....	3.00	1.00	....	14	3	....
Mild.	70°-74°	0.66	....	....	2.33	0.66	0.33	4.33	1.00	1.33	22	5	5
	65°-69°	2.66	0.33	....	4.66	0.33	....	5.33	4.66	2.00	38	16	6
	60°-64°	3.00	0.66	1.00	3.66	1.00	0.66	4.33	5.00	5.00	33	20	20
	55°-59°	3.66	1.00	1.66	7.66	1.00	1.33	4.00	5.00	3.66	46	21	20
	50°-54°	4.00	3.00	3.66	4.66	5.33	3.33	2.00	6.00	6.00	32	43	39
Cold and cool	45°-49°	5.00	5.66	2.33	4.33	5.33	4.66	2.66	4.66	6.00	36	47	39
	40°-44°	4.00	5.00	4.66	2.00	9.00	6.00	0.33	1.66	3.66	19	47	43
	35°-39°	1.00	4.00	7.33	....	5.66	9.66	....	....	1.66	12	29	56
	30°-34°	0.66	5.33	3.33	0.33	2.33	5.33	....	0.66	0.66	3	25	22
	25°-29°	....	1.33	2.66	..	0.33	1.66	....	....	....	...	5	13
	20°-24°	....	0.66	1.33	..	....	....	....	....	....	....	2	4
	15°-19°			0.33	.	....	....	....	....	....	....	....	1
Average daily maximum[†]		53.2°	40.1°	38.6	57.7°	45.9°	43.2°	64.0°	56.3°	53.2°	58.3°	47.4°	45.0°
Mean daily temperature[†]		42.9°	31.7°	28.1°	48.0°	36.8°	34.2°	56.3°	46.9°	43.9°	49.1°	38.2°	35.4°
Average daily minimum[†]		37.1°	25.9°	20.1°	40.8°	31.3°	26.7°	47.5°	40.5°	36.1°	41.8°	32.5°	27.6°

[*] No maximum data on four of the days of February, 1879, owing to breaking of the thermometer.

[†] Data taken from columns AA, C, and D, of the U. S. Signal Service charts, covering 13 years of observation.

sorts, and the distance between them being only a very few miles. So far as the mean daily temperature, the mean monthly precipitation, and the possibly occurring extremes of heat and cold are concerned, the climate of either place is doubtless well shown by the data of Table B. The close proximity of both places to the city of Norfolk also renders the U. S. Signal Service chart (Table A.) a fairly correct index of the climatic characteristics of both these resorts. To supplement both these charts, and with a view to assisting the reader toward a more accurate realization of the temperature conditions existing in the neighborhood of Norfolk during the three months of February, March, and April, I have introduced two other tables (Tables C and D). The figures in these two tables I have calculated from the recorded maximum and minimum temperatures of each day, as given in the reports of the Chief Signal Officer for the years in question. The exceptionally high temperature of the months of February and April in 1880 renders the data of both these tables untrustworthy as an index of the habitual or normal weather at any one of the three points considered; yet it seemed to me advisable to present the average of three years of observation rather than to confine myself to the data of any one year, and, as setting forth a comparison between the temperatures of the three places, the tables will doubtless be found useful and interesting to many readers of the HANDBOOK. The year 1878 is omitted because I had not in my possession the Chief Signal Officer's report for that year. The three months selected are those comprised within the season at which "Old Point" is chiefly resorted to by visitors from the North.

Climatotherapy.—As winter resorts Old Point Comfort and Newport News are in many respects similar to Atlantic City, but a comparison of the Atlantic City chart with the similar chart for Norfolk (Table A) would seem to show that these two seaside resorts of Virginia are more highly favored in the important factors of tempera-

TABLE D.

Showing the Average number of Days in the Years 1877, 1879, *and* 1880 *on which certain Minimum Temperatures were recorded in each of the Months specified. Also the actual number of Days throughout the three Seasons (a total of* 9 *Months, or* 268 *Days) on which such Minimum Temperatures were Observed.*

		February.			March.			April.			Season.		
		Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.
Warm.	65°	....	....	....	....	....	....	0.66	....	....	2	....	....
	60°–64°	....	....	....	0.33	....	....	2.33	....	....	3	....	....
	55°–59°	0.66	...	....	1.00	....	...	4.33	....	....	18	....	....
Mild.	50°–54°	1.33	....	...	1.66	....	....	3.66	2.00	0.33	20	6	1
	45°–49°	1.66	1.00	....	3.00	0.66	....	7.33	5.33	2.00	36	21	6
	40°–44°	3.00	1.00	0.33	10.00	2.33	1.33	6.00	8.33	6.00	57	35	23†
Cold.	35°–39°	8.33	2.33	2.00	9.00	3.66	2.00	4.00	8.33	9.33	64	43	40
	30°–34°	8.00	4.66	3.33	4.33	13.33	5.33	1.00	3.66	8.33	40	65	51†
	25°–29°	4.00	7.33	5.00	1.33	6.33	10.33	0.33	1.66	1.66	17	18	51
	20°–24°	1.33	5.66	4.33	0.33	2.66	5.66	0.33	0.66	1.66	6	27	35
	15°–19°	....	3.00	5.00	....	1.33	4.33	....	....	0.66	....	13	30
	10°–14°	....	3.00	4.66	....	0.66	1.33	....	....	....	....	11	18
	5°–9°	....	0.33	2.00	....	....	0.66	....	...	....	....	1	8
	0°–4°	....	....	1.00	....	...	....	....	....	....	....	....	3
	−5° to −1°	...	....	0.66	....	....	....	....	....	....	....	....	2
Average daily minimum *		37.1°	25.9°	20 1°	40.8°	31.3°	26.7°	47.5°	40.5°	36,1°	41.8°	32.5°	27 6°
Highest absolute minima observed in a period of 13 years *		30.0°	17.5°	13.0°	38.0°	22.0°	26.0°	45.0°	40.0°	34.0°	45.0°	40.0°	34 0°
Lowest absolute minima observed in a period of 13 years *		9.0°	−4.0°	−6.5°	16.0°	3.0°	−7.5°	27.0°	20.0°	11.0°	9.0°	−4.0°	−7.5°

* Data taken from columns D and F of the U. S. Signal Service charts, covering 13 years of observation.

† At Boston, in 1877, a minimum of 39.5° occurred three times, and a minimum of 29.5° occurred four times. These temperatures, in calculating data of Table D, were reckoned respectively as 39° and 29°. Had 39.5° been reckoned as 40°, and 29.5° been reckoned as 30°, the figure in the sixth line of this column would have read 26 instead of 23, that in the seventh line would have read 37 instead of 40, that in the eighth line would have read 55 instead of 51, and that in the ninth line would have read 46 instead of 51. The figures of the table have in no other instance been modified by the disregarding of fractions of a degree.

ture, relative humidity, stillness of atmosphere, and prevalence of sunshine than is their sister resort, lying 165 miles farther north, on the coast of New Jersey. With regard to relative humidity and to the mean velocity of the wind, however, it is possible that a comparison of the two charts may be misleading, inasmuch as Norfolk lies far less directly upon the coast than do either Newport News or Old Point Comfort. Moreover, the possible error as to the relative humidity of Atlantic City, depending upon the peculiarity in the situation of the U. S. Signal Office at that point, should not be lost sight of in estimating the atmospheric humidity of Atlantic City itself (see vol. i. of HANDBOOK, page 415). For cases of renal disease, places lying much farther south are doubtless to be preferred to these Virginia cape stations, and the same is true with respect to cases of serious disease of the respiratory organs, at least during the months of December, January, and February. But for those less seriously ill, "Old Point" and Newport News would undoubtedly prove serviceable places of midwinter sojourn; while for all classes of invalids resorting to our Florida, Georgia, and South Carolina health resorts, these Virginia sanatoria afford most convenient and serviceable half-way stations at which to tarry in late autumn and in spring, at both of which seasons the climate of the truly Northern States is but too well known to be trying to those who are in feeble health.

Huntington Richards.

OLEIC ACID. Oleic acid ($HC_{18}H_{33}O_2$) is the acid product of the decomposition of olein, the fluid constituent of natural oils and fats. It is officinal in the U. S. Pharmacopœia as *Acidum Oleicum*, Oleic Acid, and is thus defined: "A yellowish, oily liquid, gradually becoming brown, rancid and acid, when exposed to the air; odorless or nearly so, tasteless, and, when pure, of a neutral reaction. Sp. gr. 0.800 to 0.810. Oleic Acid is insoluble in water, but completely soluble in alcohol, chloroform, benzol, benzin, oil of turpentine, and the fixed oils. At 14° C. (57.2° F.), it becomes semi-solid, and remains so until cooled to 4° C. (39.2° F.), at which temperature it becomes a whitish mass of crystals" (U.

8 Ph.). Dr. Squibb has shown that the above cited specific gravity is undoubtedly an error, being a perpetuation of an old clerical error in transcribing the specific gravity determined many years ago by Chevreul—writing 0.808 for 0.898. The true specific gravity appears to be in the neighborhood of the latter named figure. Pure oleic acid is obtainable by a variety of processes, but the commercial oleic acid in common use in pharmacy is derived from a crude acid called *red oil*, produced in the process of manufacture of stearin candles, and contains traces of oxyoleic acid, and varying proportions of palmitic and stearic acids. Squibb (*Ephemeris of Materia Medica*) points out that this commercial acid will not satisfy the requirements for purity made standard by the Pharmacopœia in the above-quoted description, but that yet such acid is perfectly efficient for the one medicinal purpose of oleic acid—the making of "oleates."

The medicinally valuable property of oleic acid is that while retaining the physical properties of a fixed oil, the acid is yet of high diffusive power, thus readily, upon inunction, passing through the unbroken skin into the general circulation, and leaving behind a smooth, soft and supple, but not greasy condition of the integument. Being an acid it forms salts with salifiable bases, many of which salts are soluble in excess of oleic acid. Such solutions of oleates in oleic acid are found to permeate the skin as readily as the simple acid, and for this reason such solutions form a class of medicines defined as "oleates," and devised as means of medicating the general circulation through the unbroken skin. Oleic acid is used exclusively for the manufacture of these pharmaceutical "oleates." *Edward Curtis.*

OLETTE is a small town in the Département des Pyrénées-Orientales, France, about ten miles from the city of Prades, lying at an elevation of about 1,900 feet above the level of the sea. The climate is that common to elevated regions, hot in the middle of the day, but cool, and even cold, in the morning and evening. The medicinal springs at Olette are very numerous, there being upward of forty in the town and its immediate neighborhood; they belong to the group of alkaline sulphur springs. The water is clear and transparent, of an odor recalling that of the white of a hard-boiled egg, and of a slightly bitter and distinctly sulphurous taste (Rotureau). The temperature of the different springs varies from 27° to 78° C. (80° to 172° F.). The following is the composition of two of these springs according to an analysis made by M. Bouis in 1852. The computation is made in grammes per litre.

	Source Saint-Andre.	Source de la Cascade.
Potassium	0.00821	0.00940
Calcium	0.03542	0.03841
Sodium	0.00813	0.00755
Sodium sulphide	0.02829	0.03040
Sodium carbonate	0.04785	0.04842
Sodium sulphate	0.06500	0.06200
Sodium chlorine	0.02160	0.02200
Silica	0.14300	0.16400
Aluminum, iron, manganese, iodine	0.05000	0.04200
Organic matters	0.03460	0.03600
Total solids	0.43150	0.46966

The potassium, sodium, and calcium, given as uncombined in the above table, exist probably as silicates.

The waters are employed internally, and in the form of baths. They are recommended as of great efficacy in the treatment of various neuroses, urinary gravel, rheumatism, chronic catarrhal affections of the respiratory organs, and various forms of obstinate skin affections. The season extends from the end of May to the beginning of October. A course of treatment is completed in from three to four weeks. *T. L. S.*

OLIBANUM (*Encens, Oliban*, Codex Med.; Frankincense). This interesting and agreeably smelling substance is obtained from *Boswellia Carteri*, Birdwood, and probably from other species of the genus. Although there are few substances of more ancient record than this, the inhospitable character of the countries where it is obtained has prevented any knowledge of its real source until rather recently, and even that which we have at present is far from complete. The plant above mentioned was discovered in south-eastern Arabia by Mr. Carter, and afterward found to be abundant in the Somali Land of eastern Africa. It is a large, fine, graceful shrub or small tree, with branching trunk and stout, cylindrical branches, bearing long, pinnate, alternate leaves. Leaflets oval, crenate, smooth above, and light, downy, or hairy beneath. The flowers are small, white, and in large terminal panicles. It inhabits barren limestone cliffs and deserts near the coast. The bark and wood abound in milky juice, which hardens as it exudes into the tears of which Olibanum consists. The tree is said to be deliciously fragrant when in blossom, and to fill the whole region with its perfume. Besides this, there are several other species of *Boswellia* growing in the same localities which may contribute a share of the product.

In order to procure Olibanum, the collectors at the proper seasons (May and December in Arabia, March in eastern Africa) seek the trees and make deep cuts through the bark, from which the milk-white liquid rapidly flows and either dries at the wound or runs down the trunk. The operation is repeated from time to time, and after a few weeks, when the exudation has hardened sufficiently, it is collected. The Olibanum of commerce comes exclusively from these two localities, and is generally carried first to Bombay, whence the portion used in Europe and this country is mostly shipped.

This substance is repeatedly mentioned in the Bible; and evidences of its use have been found in ancient Egyptian structures. Theophrastus, Plutarch, Herodotus, and other writers of antiquity refer to it or describe its importance. It is an ingredient of the incense of the Greek and Roman churches, and is, besides, used in the ceremonies of some of the Asiatic religions.

Description.—Olibanum consists of rounded, or oblong and irregular tears, from the size of a small bean or less up to an inch or so in length, of hard and brittle consistence. The surface is dull and waxy, sometimes freely dusted with its powder by attrition, color yellowish-brown, translucent in thin pieces, pretty opaque in the larger ones. Odor peculiar, aromatic, slightly terebinthinous, pleasant, especially when heated; taste at softens in the mouth) terebinthinous and moderately bitter.

Composition.—Like Myrrh, which Olibanum nearly resembles, Olibanum softens in water in consequence of the presence of about one-third of its weight of a *gum* resembling acacia, and rubbed fine in water it forms an emulsion. The remaining two-thirds, excluding impurities, such as dirt, bits of bark, etc., are mostly a *resin*, soluble in alcohol, and about five per cent. of *essential oil*.

Action and Use.—There is little to be said of this substance that does not apply to the mild resinous substances in general: Applied to the skin, it is gently irritant; internally, it is slightly laxative and stimulant; it is said to be expectorant, and undoubtedly to some degree is a stimulant diuretic. It is, however, now never given so, and excepting as a component of deodorizing pastils, may be said to be obsolete as an article of the Materia Medica.

Allied Plants, Etc.—See Myrrh. *W. P. Bolles.*

OLIVE OIL (*Oleum Olivæ*, U. S. Ph.; Br. Ph.; *Olea Olivarum*, Ph. G.; *Huile d'Olive*, Codex Med.; Sweet Oil, Salad Oil, etc.). The fatty oil expressed from the fruits of the Olive-tree, *Olea Europæa* Linn.; Order, *Oleaceæ*.

The Olive is a small or medium-sized tree, with a much-branched trunk and numerous slender branches. The bark is gray, the wood compact, rather hard, agreeably scented, and susceptible of a high polish. Its fine yellow color, variegated with brown, in addition to the above qualities, make it a favorite material for small wooden ornaments and pieces of furniture.

The leaves are opposite, evergreen, short-petioled, lanceolate, entire, and coriaceous; they are pale green and smooth above; silvery white beneath, in consequence of a

layer of stellate hairs. Flowers in small axillary panicles, white, with a short calyx, a four-parted corolla about five millimetres across, bearing two very short stamens, and a two-celled four-ovuled free pistil. The fruit, the well-known Olive, is an oval, pointed drupe, about two or three centimetres (one inch) long, consisting of a firm, very oily mesocarp, and a spindle-shaped, hard putamen, containing a single long and narrow, also oily, seed. Its color when ripe is dull blue or purple, its taste bitter and oily.

This valuable tree is a native of Asia Minor, Palestine, and other parts of the Levant, where its cultivation is of the greatest antiquity, as the Old Testament and numerous ancient records show. It was introduced into the Mediterranean countries of Europe and Africa also at an early date, and has become thoroughly naturalized in some of them. In the course of time it appeared in the warmer parts of South America and elsewhere in the tropics, as well as in California in this country.

The fruit of the Olive has been improved in form and size, as well as flavor, by cultivation, and there are several well-distinguished varieties. The Olive is one of the most important products of Spain and Italy.

For the table Olives are gathered while still green, but fully grown, soaked in water or sometimes in lye to remove their natural bitterness, and finally pickled in a simple or sometimes flavored brine. For the Oil they are allowed to ripen, ground and subjected to pressure.

The quality of the product depends upon nicety in every stage of the operation; for the best table-oil fine fruits of good varieties must be taken, and the pressing done at once, without heat; this yields a moderate quantity of very clear, light-colored, generally slightly greenish, pleasant-flavored oil, generally called "Virgin Oil," which is sold for table-use. The remaining cake is then broken up and heated or mixed with boiling water and more strongly pressed, when a further product of darker and stronger-tasting oil is obtained, that can be used for cooking or fuel. An easy way, finally, for obtaining a large yield of oil is to lay the Olives in heaps until decomposition begins, when a very strong oil (*huile fermentée*) results.

FIG. 2541.—Branch of Olive; about one-half natural size. Flower and section of same enlarged. (Baillon.)

COMPOSITION.—No other fruit contains so large a proportion of fixed oil as this; generally over one-half, and in good qualities almost three-fourths. Besides, the fruit contains considerable *mannit*, diminishing as it ripens and the oil increases. Olive Oil (*Oleum Olivæ*, U. S. Ph.) of the quality required for medicinal purposes is thus described: "A pale yellow, or light greenish-yellow, oily liquid, almost devoid of odor, having a nutty, oleaginous taste, with a faintly acrid after-taste and a neutral reaction. Specific gravity, 0.915 to 0.918. Sparingly soluble in alcohol, but readily soluble in ether. When cooled to about 10° C. (50° F.), it begins to be somewhat cloudy from the separation of crystalline particles, and, at about 5° C. (41° F.), it begins to deposit a white, granular sediment; below 2° C. (35.6° F.), it forms a whitish, granular mass." The principal part, more than two-thirds, of Olive Oil is the liquid fat *olein*, or triolein; nearly all the rest is *palmitin*, with a little *stearin*, *butin*, and perhaps also *cholesterin*. Of the so-called "Olive Oils" in the American market the cheaper ones, even bottled and labelled in French as "Pure Olive Oil from Nice," etc., are at present almost entirely better grades of cotton-seed oil, and some of the more expensive sorts are said to be adulterated with it. This oil and other cheaper ones are also used abroad extensively as substitutes for or adulterants of this delicious and much-prized substance.

ACTION AND USE.—This can be disposed of quite briefly, so far as its medical use is considered. Given internally, it is chiefly a fatty food, and is emulsified and absorbed as other fats are. It is slightly, only very slightly, laxative, and has no other physiological action. Locally applied it is a neutral protective from the atmosphere also, like other fats, and in this application has given place somewhat to cheaper ones—suet, lard, cotton-seed oil, etc., and especially to the various *petrolatum* manufactures.

It is rather frequently given as an injection, but *Castor-oil* is preferable for this purpose. Its most extensive employment in medicine is perhaps in the composition of several liniments and of the pharmaceutical soaps; in

this field it is also of late replaced in this country by the cheaper oil from cotton seed.

Administration.—As a laxative, three or four tablespoonfuls are required, a dose that is apt to disturb the stomach of one unaccustomed to oils. As an injection, one or two teacupfuls, injected warm, and retained an hour or so and then followed by soap-suds, make a very efficient composition for relieving an overloaded rectum. The following preparations contain it: (*Emplastrum Plumbi*, U. S. Ph.) Lead Plaster, and (*Unguentum Diachylon*, U. S. Ph.) Diachylon Ointment. The other ointments and most liniments were formerly made with it.

Allied Plants.—The genus contains upward of thirty species, mostly natives of the Mediterranean basin, some of which produce an oily fruit that possibly might be utilized, but only this is in cultivation. The order includes also the Ash trees (see Manna), Lilacs (*Syringa*), Privet (*Ligustrum*), *Forsythia*, and other useful and ornamental plants.

Allied Substances.—Olive Oil is the type of non-drying oils, of which almond, rape, colza, mustard, peanut, are other examples; it is nearly related, also, to cotton-seed, sesame, and several nut-oils. The principal drying-oils (having *linolein* as their basis) are linseed, hempseed, poppy, walnut, etc., oils. The animal oils are also nearly similar products, but castor and croton oils contain drastic principles that separate them widely from those just mentioned. *W. P. Bolles.*

OLYMPIAN SPRINGS. *Location and Post Office*, Olympian Springs, Bath County, Ky.

Access.—By Chesapeake & Ohio Railway, Lexington Division, to Olympian Springs Station, thence by conveyance two and one-half miles to the springs.

Analysis.—One pint contains:

	Grains.
Carbonate of magnesia	0.904
Carbonate of iron	trace
Carbonate of lime	1.742
Chloride of potassium	1.334
Chloride of sodium	20.752
Chloride of magnesium	6.924
Sulphate of lime	trace
Bromide of iron	trace
Alumina	trace
Silica	0.131
Total	31.787

Carbonic acid gas and sulphuretted hydrogen not estimated.

Therapeutic Properties.—This resort comprises a group of five springs, which, though varying somewhat in actual composition, are salt-sulphur. Several, in addition, contain iron (carbonate) and carbonate of soda.

The waters are used in skin, joint, and glandular diseases.

These springs are situated in the northeastern part of Kentucky, amid the beautiful mountain scenery of that healthful section. There is an hotel at the springs.

ONONIS SPINOSA (*Radix Ononidis*). The dried cylindrical root of the plant above named (order *Leguminosæ*), and often, although not officially, of one or two other species of *Ononis*. It is a good-sized, branching perennial root, with several crowns above, of a grayish-brown surface, and soft, woody structure. It has a disagreeable, astringent, bitter taste, and but little odor. The principal constituents are *resin*, *tannin*, a crystalline substance, *ononin*, and a sweetish-bitter amorphous one, *ononid*, neither of them active.

Ononis is a nearly obsolete family medicine, which has had reputed value as a diuretic and "blood-purifier." There appears to be no reason for retaining it in use.

Allied Plants, Etc.—See Senna. *W. P. Bolles.*

ONTANEDA Y ALCEDA, two small places in the province of Santander, Spain, constitute a thermal station which has recently begun to enjoy a considerable reputation in the treatment of rheumatic and syphilitic affections. The two towns of Ontaneda and Alceda are at a distance of about a mile from each other, but they form practically but one establishment. The following is the composition of the Ontaneda water. One litre contains of—

	Grammes.
Calcium sulphate	1.770
Potassium sulphate	0.486
Sodium sulphate	0.347
Magnesium chloride	1.080
Sodium chloride	0.980
Calcium bicarbonate	0.039
Magnesium bicarbonate	0.024
Silica	0.011
Ferrous oxide	0.005
Total solids	4.742

The temperature of the water is 33.3° C. 82° F.).

In addition to the indications above mentioned, much benefit is often derived at this spa by patients suffering from non-syphilitic skin affections, indolent ulcers of the leg, varicose veins, and affections of the urinary apparatus. The season here extends from the first of June to the first of October. *T. L. S.*

OPHTHALMOSCOPE; OPHTHALMOSCOPY, from ὀφθαλμός, eye, and σκοπέω, to look at. The ophthalmoscope, German, *der Augenspiegel*, is an optical device by the aid of which the interior of the eyeball may be viewed.

Ophthalmoscopy, in its wider meaning, includes whatever pertains to the objective examination of the eye; in a narrower sense, it is often restricted to the examination of the eye by the aid of the ophthalmoscope.

The anterior segment of the eyeball, comprising the cornea, the anterior chamber filled with the aqueous humor, the front of the iris, and so much of the anterior capsule of the crystalline as corresponds to the area of the pupil, is accessible to direct inspection by the naked eye, or through a magnifying glass. Even when the pupil is strongly contracted, a central opacity of the lens-capsule or of the immediately subjacent lens-substance reveals itself by a characteristic white or gray appearance; when the pupil is widely dilated, we may look into or through the crystalline, and thus sometimes obtain glimpses of a detached and displaced portion of the retina, of a blood-clot or other large foreign body in the vitreous, or of the surface of a very prominent tumor arising from the retina or choroid.

Let L (Fig. 2542) represent a pencil of parallel rays of light, such as a sunbeam, entering the dilated pupil *a a'*

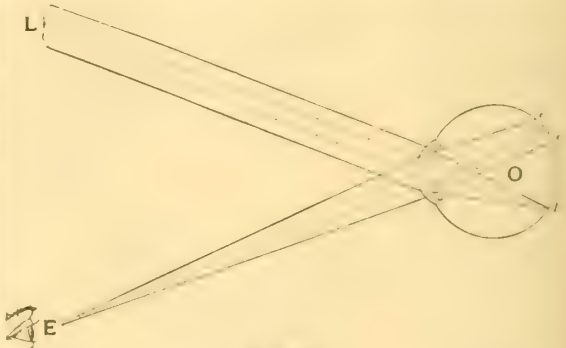

Fig. 2542.

of the eye O, and lighting up a path through the vitreous as indicated by the cone *a a l*. The eye of an observer stationed at E will receive rays from any object which may happen to lie within that portion of this cone, near its base, which is cut off by the line *a a''*; outside of the limits *a a' a''*, the whole interior of the eye, O, is either in comparative darkness or is shut off from view by the iris at *a a'*. If the pupil is contracted to the diameter *b b'*, only such part of the pencil L as is included within the dotted lines can enter the eye O, and only such objects as happen to lie within the smaller cone *b b' l* will be illuminated; even of this smaller cone the greater portion is shut off from view by the iris at *b b'*, so that nothing can be seen outside the narrow limits *b b' b''*. It is evident

from the construction that the distance to which we can see directly into the depths of the eye is very largely determined by the diameter of the pupil. With a small pupil we can, at the farthest, see only a little way into the crystalline lens; with a widely dilated pupil we may look well into the vitreous.

The smaller the angle which the axis of the eye of the observer makes to the axis of the illuminating pencil, the

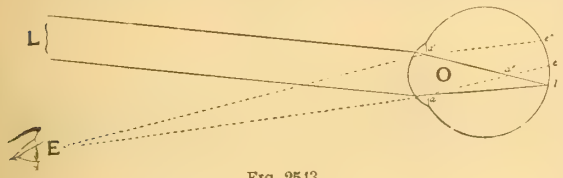

Fig. 2543.

farther back in the observed eye will lie the point a'', and the deeper will it be possible to see into the eye (see Fig. 2543).

If this angle is taken very small—approaching zero as a limit (see Fig. 2544)—the point a'' will recede to or beyond l, in which case the small illuminated area at l will lie in part or wholly within the field of view $e\,e'$, commanded by the eye at E. The precise case assumed is,

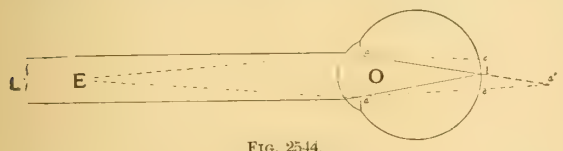

Fig. 2544.

however, an impossible one, inasmuch as the interposed head of the observer at E must necessarily shut off all the illuminating rays coming from the direction of L.

Whenever the refraction of the observed eye, O, is greatly below the normal, as in hypermetropia of high grade, the illuminating pencil will be cut by the retina before reaching a focus (see Fig. 2545), and will light up an area at the fundus, which area will be larger or smaller according as the pupil is more or less dilated, and

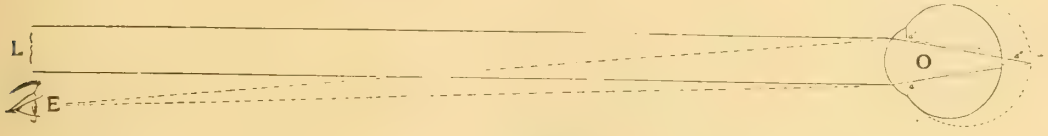

Fig. 2545.

the pencil is cut at a greater or less distance from its focus. An observer looking into the eye, at a small angle to the axis of the illuminating pencil, may receive rays of light from some part, of this illuminated area, and will then see the pupil of the observed eye more or less perfectly illuminated, and of a red color—*das Augenleuchten*. To develop this phenomenon by daylight, the pupil of the observed eye must be well dilated, in order both that the illuminated area may be as large as possible, and that the iris at $a\ a'$ may cut off as little as may be of the view into the eye. The appearance of a shining pupil is best produced when the observer is stationed with his back to a window, and looks into the face of another person, with dilated pupils, whose eyes are directed toward but are not accommodated for, a bright cloud in the sky, or perhaps the window itself, if glazed with ground glass or covered by a translucent white shade. Shining of the pupils is also very conspicuous, under favorable conditions, in certain animals with eyes of hypermetropic construction and whose fundus is partially clothed by a strongly reflecting layer—the tapetum. A familiar instance is the shining of the eyes of the cat, when the gaze of the animal, with pupils widely dilated, is encountered by a person entering a dark room with a lighted lamp. In persons with congenital or acquired absence of the iris—*aniridia*, *irideremia*—the eyes are similarly seen to glow by lamplight. The vivid red color of the pupils of albinos is not dependent on the refractive condition of the eye, but is a result of the lighting up of the whole interior of the eyeball through the unpigmented and abnormally translucent iris and choroid; when the eye of an albino is shaded by an opaque card, the pupil, viewed through a hole in the card, appears black, as in a normally pigmented eye.*

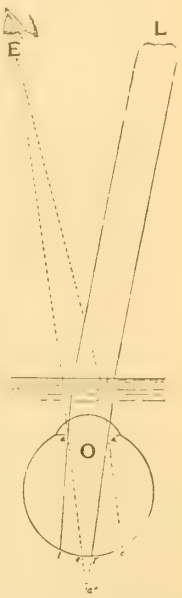

Fig. 2546.

If we annul the refraction at the cornea by plunging the head of an animal under water (see Fig. 2546), the eyes will be rendered very strongly hypermetropic, and the pupils may be seen to shine brightly by ordinary daylight. In this experiment it may even be possible to see some of the details of the fundus through the widely dilated pupil (*cf.* Fig. 2545).†

If the observed eye is strongly myopic, the illuminating pencil will converge to a focus (see Fig. 2547) at some point in the vitreous humor, and, continuing on its course, will light up the area $l'\ l$ where it is cut by the retina. As in the case of the hypermetropic eye (*cf.* Fig. 2545), a portion, $e'\ l$, of this illuminated area will fall within the field of view commanded by the eye of an observer stationed at E, who will then see the pupil of O lighted up.

If we take as the source of light a candle-flame, or, still better, a small incandescent electric lamp, L (see Fig. 2548), fifteen centimetres (six inches) or more from the observed eye O, and look as nearly as possible in the direction of the illuminating pencil, the illuminating pencil will be cut by the retina before reaching its focus, and a part of the fundus $l\,l'$ will be lighted up. In this case, as in the cases assumed in Figs. 2545 and 2546, the point a'' will lie outside the eye, and a portion, $e\,l'$, of the illuminated area $l\,l'$ will fall within the region $e\,e'$, from which rays of light can enter the eye of an observer stationed at E, behind and a little to one side of the lamp. Under these conditions the pupil of O will appear strongly illuminated.‡

* The shining of the eyes of certain animals in the dark was, for a long time, attributed to a supposed power of generating light: in other words, to a true phosphorescence. Prevost (1810) showed that the phenomenon is not observed in the dark, but only when the eyes are illuminated by light falling directly upon them from without. Rudolphi (1810) called attention to the fact that it is necessary to look into the eye in a particular direction. In aniridia of the human eye Berr (1839) saw the pupils red and shining when he looked at the eyes in nearly the direction from which the light fell upon them; W. Cumming (1846) and Brücke (1847) discovered, independently of each other, that the pupils of the normal human eye may be made to shine, under the same conditions of illumination and inspection (cited from Helmholtz: Handbuch der physiologischen Optik, S. 189).

† Mery (1704) first described this experiment, in which probably the first view of the blood-vessels in the retina of a living animal (cat) was obtained. The visibility of the details of the fundus in this experiment was correctly ascribed by La Hire (1709) to the alteration in the conditions of refraction, of which, however, he failed to give any exact explanation (cited from Helmholtz, op. cit., S. 190). By the aid of the orthoscope of Czermak, a little glass-trough, fixed to the cheek and nose with putty, and filled with water, the observation of Mery may be repeated upon the human eye.

‡ This arrangement of the light represents essentially that employed by Brücke (1847) in his demonstration of the lighting up of the human eye. Brücke used a lamp or a candle as the source of light, and shut off the light from the eye of the observer by means of a small opaque screen.

If we move the lamp L nearer to the eye O, the angle LOE will become larger and larger, and the portion e' of the illuminated area ll', falling within the field ee', will

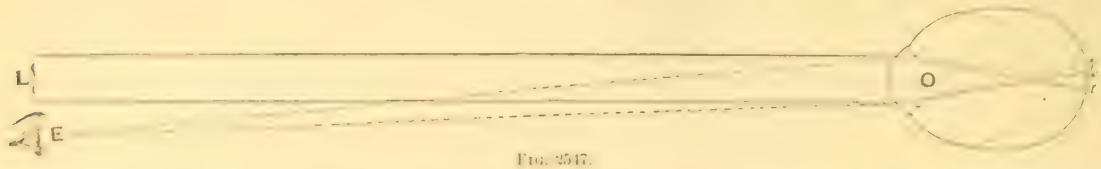

Fig. 2547.

become smaller and smaller, and whenever the angle LOE becomes so large that no part of ll' coincides with any part of ee', the pupil will cease to appear luminous.

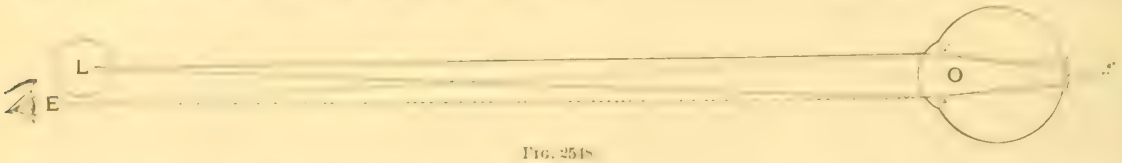

Fig. 2548.

If, however, we mount a small refracting prism, P, in front of the incandescent lamp at L (see Fig. 2549), we may so change the direction of the illuminating pencil as

Fig. 2549.

to turn it upon the eye O, as if emanating from L', thus permitting an observer to look into the eye from E, at a very small angle to the axis of the illuminating pencil, even though he approach as near as about five centimetres (two inches) to the cornea of the observed eye.

The most convenient and at the same time thoroughly effective way of lighting up the fundus of the eye is by making use of a reflector. This reflector may be made of unsilvered transparent glass, in which case it must be set at an angle of forty-five degrees or less to the direction of the axis of the illuminating pencil (see Fig. 2550). Of the incident rays, a portion will be transmitted by the transparent glass, and lost, while another portion will be

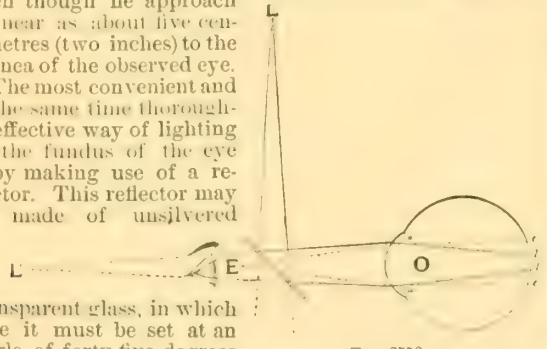

Fig. 2550.

regularly reflected, and may be directed upon the pupil of the observed eye O, as if they had emanated from L'. So, also, in the case of the efferent pencils, a portion of the rays will be lost by reflection in the direction of the light L, while another portion will be transmitted by the glass, and may be received by the eye of an observer looking through the transparent mirror directly in the axis of the illuminating pencil.*

A plane mirror of silvered glass, or of polished metal, may be substituted for the mirror of transparent glass, with the double advantage of reflecting a much stronger light into the eye and of permitting the lamp to be placed by the side of and at any required distance behind the patient's head (see Fig. 2551). An observer looking past the side of the mirror, or, more conveniently, through a

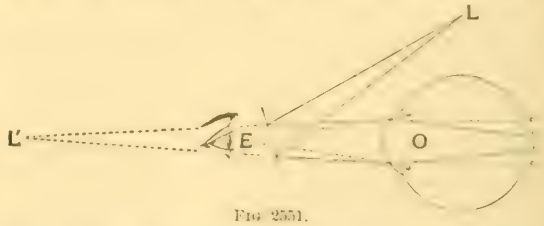

Fig. 2551.

small central perforation, will see the pupil of the eye O more strongly illuminated than when an unsilvered glass mirror is used. The farther the plane mirror is held from the observed eye the smaller will be the portion of its reflecting surface from which rays of light can enter

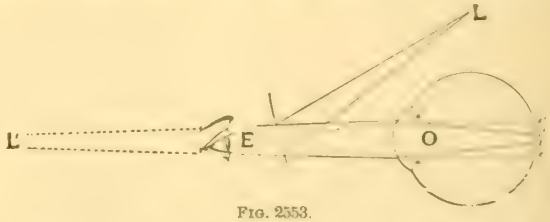

Fig. 2553.

the pupil (see Fig. 2552), and the weaker will be the illumination.

By making use of a concave mirror, and varying the distance of this mirror from the lamp and from the observed eye, we may either reproduce essentially the same

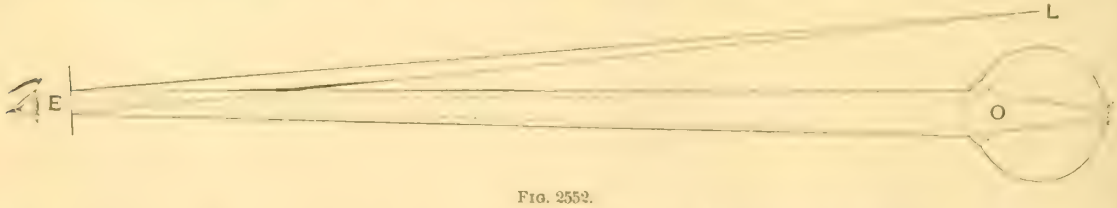

Fig. 2552.

conditions of illumination as when the plane mirror is held near the eye (see Fig. 2553—*cf.* Fig. 2551), or, increasing the distance of the lamp, we may throw at will

* The arrangement shown in Fig. 2552 is essentially that employed by Helmholtz (1851), the inventor of the ophthalmoscope.

a parallel (see Figs. 2554 and 2555) or a convergent pencil (see Fig. 2556) into the eye. If we increase the distance at which the mirror is held from the eye, and from the

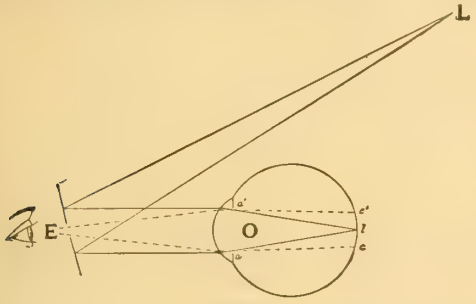

Fig. 2554.

lamp (see Fig. 2557), a larger convergent pencil, reflected from the entire surface of the mirror, may be thrown into the observed eye, and when the lamp and the pupil of the eye, O, come to lie in conjugate foci of the mirror (see Fig. 2558), the size of the illuminating pencil will be

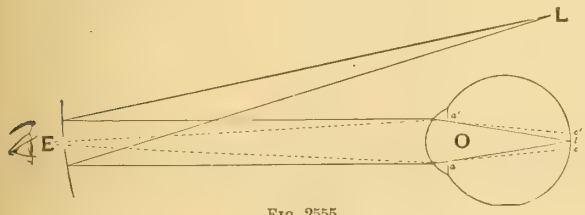

Fig. 2555.

limited only by the diameter of the mirror, however large it may be, and the illumination at the fundus will be proportionally intense. A concave mirror of very thin, silvered glass of a diameter of 33 millimetres (1.3 inch), of a focal length of 22.5 centimetres (9 inches), and with a central perforation of about 3.5 millimetres (.14 inch),

either moderately divergent, parallel, or convergent, thus producing, by refraction, the same forms of pencils as are produced by reflection from the concave mirror (*cf.* Figs. 2553 to 2558).

If the illuminating pencil is made to pass through a convex lens of short focus, held in front of and at somewhat less than its principal focal distance from the cornea of the observed eye, a very large convergent pencil may be concentrated upon the pupil, and focussed within the eye at a depth which will be inversely as the power of the lens and the distance at which it is held in front of the eye. With a convex lens of about 20 dioptrics

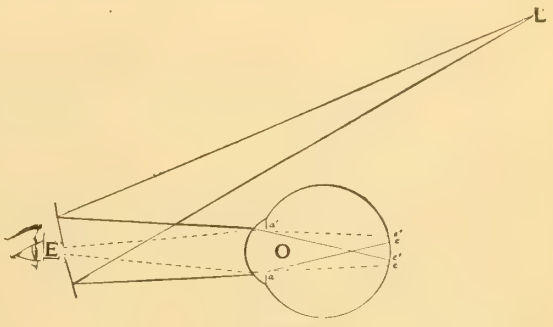

Fig. 2556.

(5 centimetres = 2 inches focus) held at a distance of about 4.5 centimetres (1.8 inch), in front of the cornea (see Fig. 2559), the focus will lie in the vicinity of the nodal point of the eye, and a large area of the fundus, limited only by the angular diameter of the convex lens, will be strongly illuminated.

If a weaker lens is employed, or if the lens of 5 centimetres focus is held nearer to the observed eye, the focus of the illuminating pencil will lie at some point in the vitreous humor, and the illuminated area at the fundus will be larger or smaller according as the focus lies farther from or nearer to the retina. When the focus lies at a certain depth in the eye the diameter of the illu-

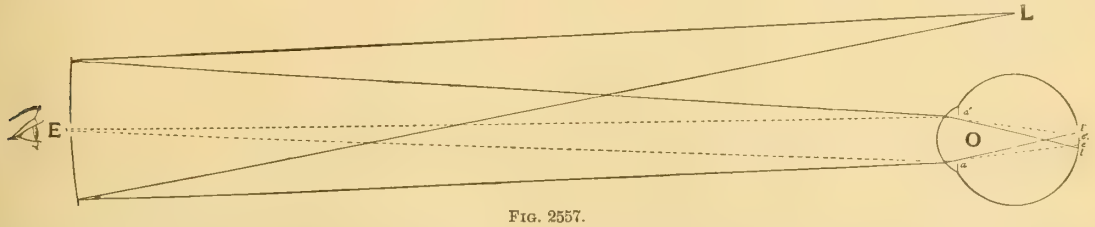

Fig. 2557.

is found to be, on the whole, most convenient, as serving both for such examinations as are required to be made with the mirror held near the eye (see Figs. 2553 to 2556) and for those in which it is required to reflect a large convergent pencil from a greater distance (see Figs. 2557 and 2558).

minated area will be further limited by the size of the pupil, in which case only that part of the illuminating pencil which corresponds to a larger or smaller central portion of the convex lens will gain entrance into the eye (see Fig. 2560).

If a stronger convex lens is used, or if the lens of 5

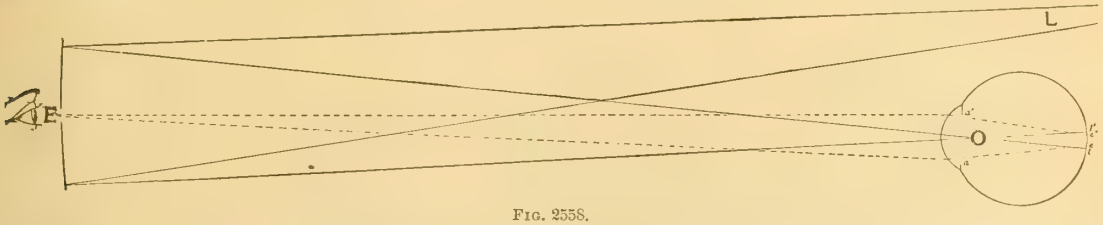

Fig. 2558.

The little electric lamp shown in Fig. 2548 may be fitted with a short draw-tube containing a weaker or stronger convex lens, or combination of lenses, like the condensing lens of a magic lantern; by varying the distance of the lens or of one of the lenses from the incandescent filament, a very large pencil may be rendered

centimetres focus is removed to a little more than its focal distance from the observed eye (see Fig. 2561), the focus of the illuminating pencil will lie a little in front of the cornea and the fundus will be illuminated in an area somewhat larger than under the conditions assumed in Fig. 2559, which area, as in that case, will be limited,

practically, only by the angular diameter of the convex lens.

In all three positions of the convex lens some part of the illuminated area of the fundus will fall within the field of view commanded by the eye of an observer looking into the observed eye at even a somewhat large angle to the direction of the illuminating pencil, and if the point of view is taken at a small angle to the illuminating pencil, as at E (Figs. 2559 to 2561), rays emanating from a large portion of the illuminated area may enter the eye of the observer.

By combining the perforated concave mirror of about 22.5 centimetres (9 inches) focus, with a convex lens of

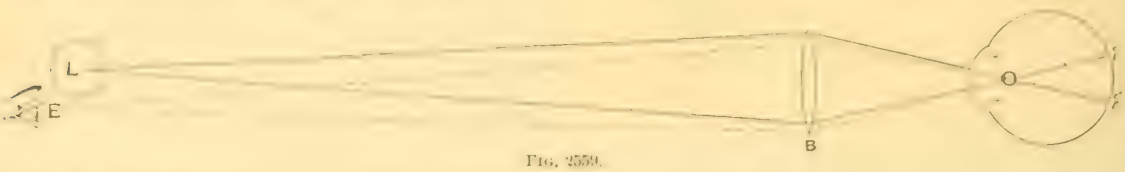

Fig. 2559.

5 or 6 centimetres (2 or 2.4 inches) focus, the maximum useful degree of illumination is attained, together with the ability to regulate the diameter of the illuminated area at the fundus by varying the distance at which the lens is held from the eye. The observer looking through the central perforation in the mirror, directly in the axis of the illuminating pencil, is also in the most favorable position for receiving rays from the large illuminated area at the fundus (see Fig. 2562).*

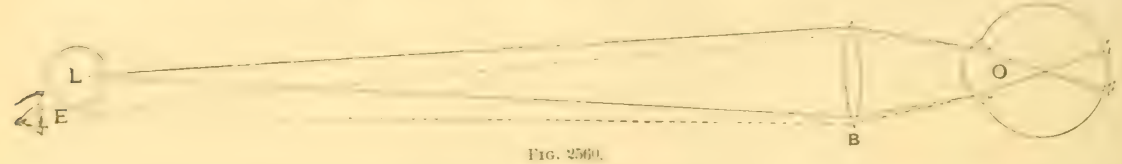

Fig. 2560.

We have thus far, for the sake of simplicity of demonstration, considered the source of light as a luminous point, which we have taken either at an infinite distance (see Figs. 2542 to 2547), or at some short distance, as indicated by the position of the minute incandescent loop of the small electric lamp (see Figs. 2548 to 2562). As a matter of convenience, however, we almost always make use of an oil-lamp or gas-burner, in which case the minimum area of illumination at the fundus is represented by the inverted image of the flame when focussed accurately upon the retina (see Fig. 2563). Whenever the observed eye is adjusted for any distance other than the actual or virtual distance of the source of light, the several points in the illuminating flame are projected as circles of confusion in the retinal image, which then presents more or less perfectly the form of the flame, according as the several pencils are more or less accurately focussed (see Figs. 2564 and 2565). The maximum intensity of illumination is attained when the illuminating pencils are focussed exactly in the retinal image, as in Fig. 2563, and when the pupil is widely dilated, so as to admit pencils of the greatest possible size.

The lamp ordinarily used in ophthalmoscopic work is an Argand oil-lamp (the so-called student's lamp), or an Argand gas-burner, with some arrangement for adjusting it to about the height of the patient's head. A petroleum lamp with a broad flame, of which the best form is perhaps the so-called duplex burner, or a bat-wing gas-jet, may also be used; both offer a certain advantage by reason of the greater width of the flame. There is also some advantage in surrounding the flame by an opaque screen, or second chimney, of metal, with an opening of from 2.5 to 3.5 centimetres (1 to 1.4 inch) diameter at the side turned toward the mirror. The distance of the lamp from the observed eye (OE - EL, Figs. 2552, 2557, 2558, and 2562) should ordinarily not exceed about 75 centimetres (2½ feet), but it may in many cases be much less (*cf.* Figs. 2550, 2551, 2553, 2554, 2555, and 2556).

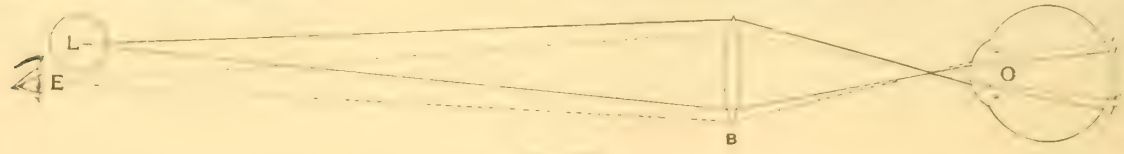

Fig. 2561.

A minor disadvantage in using oil or gas illumination is the yellow color of the flame, which imparts to the whiter portions of the fundus a somewhat unnatural tint. The true color of the fundus is best observed by indirect sunlight, either reflected from a bright cloud or admitted into the darkened room through a hole in the shutter, which may be glazed with ground glass or covered with thin white paper. Direct sunlight is by far too intense to be safely thrown into the eye, even when reflected from an unsilvered glass mirror; the light of the full moon is, on the other hand, insufficient, except when reflected from a very large concave mirror.

Fig. 2562.

* The illumination by means of the perforated concave mirror, or by the employment of the convex lens to form an inverted image of the flame at or near its anterior focus (Ruete, 1852), is designated as monocular, as contrasting in importance to that of Helmholtz (Figs. 2559 to 2561 inclusive), a development of Brücke's experiment (by Helmholtz, 1852), in which the convex object-lens of Ruete is employed.

The size of the illuminated area, *i.e.*, of the bright image of the flame, is in an inverse ratio to the distance (LO, L′O, L″O, Fig. 2563) of the lamp from the nodal point of the observed eye (*cf.* Figs. 2548 and 2549), or, in the case of the reflection of the illuminating pencils by a plane mirror, to the distance LE + EO (Figs. 2550 to 2552); whenever the illuminating pencils are imperfectly focussed, the image is further spread out, at its borders, in a width equal to the radius of the circle of confusion in which any single point in the flame is projected on the retina. When a concave mirror is used, and the distance from the observed eye is large (see Figs. 2557 and 2558), the illuminated area becomes approximately the image of the mirror.

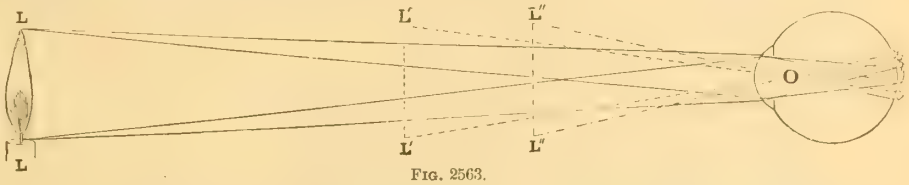

Fig. 2563.

The extent of the area at the fundus, which falls within the field of view of the observer in the direct method of examination—*i.e.*, without the interposition of the convex lens—varies directly as the size of the pupil of the observed eye, and inversely as the distance from the eye at which the observer is stationed (see Figs. 2550, 2551, 2553, 2554, 2556. and 2552, 2555, 2557, 2558); a fairly large pupil and a near point of observation are therefore essential to the enjoyment of an ample field. To secure a near point of observation, we hold the ophthalmoscopic mirror as near as possible to the observed eye (see Figs. 2550, 2551, 2553, 2554, and 2556), and to avoid contraction of the pupil under the stimulus of the light reflected into the eye, we may instil a drop of a weak mydriatic solution, or we may make use of a mirror which reflects light of the minimum intensity compatible with sufficient illumination. If we employ a mydriatic we choose, by preference, a solution of homatropine (1 : 250), or of cocaine (1 : 50), or perhaps of atropia (1 : 2,000), either of which will sufficiently dilate the pupil in the course of from ten to thirty minutes, without subjecting the patient to the inconvenience incident to the prolonged mydriasis which follows the instillation of a strong solution of atropia, duboisia, or hyoscyamia. To reflect a weak light into the eye, we may use a perforated plane or concave mirror made of darkly tinted glass, or, still better, the original form of mirror devised by Helmholtz, which is made up of two or more plates of thin, unsilvered glass. This compound mirror not only reflects more light than does a single plate of glass, but it also polarizes the reflected pencils in a high degree, and, by its action as an analyzer, extinguishes most of the rays which, in certain positions, are reflected back from the surface of the cornea, and constitute a serious hinderance to the view of the parts within the eye.

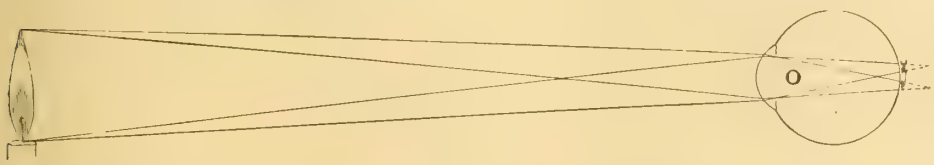

Fig. 2564.

In the indirect method of examination—*i.e.*, by the use of the strong convex lens held at about its focal distance in front of the observed eye—the size of the pupil plays a much less important part than in the examination by the direct method, and in certain positions of the lens it is altogether eliminated as a factor in determining either the intensity of the illumination or the amplitude of the field of view. This is the case whenever both the focus of the illuminating pencils and the intersection, within the eye, of the lines which define the limits of the field of view lie in or very near to the plane of the pupil (see Fig. 2559); and the same is approximately true when the distance of the convex lens from the observed eye is so adjusted that the two points in question fall, the one a little in front of, and the other a little behind the plane of the pupil (see Fig. 2562). Only in extreme contraction of the pupil, in which case its area may be smaller than the inverted image of the illuminating flame, is there any material falling off in the brilliancy of the illumination; but when the pupil is very small, the focus of the illuminating pencils and the crossing of the lines limiting the field of view must both lie almost exactly together, in the plane of the pupil; this condition is perfectly realized whenever the distance of the lamp from the observed eye is about the same as the distance of the eye of the observer (see Fig. 2559), but not so perfectly when the mirror is used. In indirect examination, therefore, there is a limit beyond which the contraction of the pupil may make it difficult to light up the fundus, and at the same time to obtain a satisfactory view; but this difficulty does not ordinarily arise unless the contraction considerably exceeds the usual physiological limit.

Whenever the image of the flame, as projected on the retina, is notably smaller than, and lies wholly within the field of view commanded by the eye of the observer (see Figs. 2550 to 2556), the form of the image may be seen through the pupil, with outlines more or less distinct, according as it is itself sharply defined and as the refractive condition of the observed eye is such as to admit of the efferent pencils being accurately focussed upon the retina of the observer. Outside of the limits of this bright image, the circular field corresponding to the pupillary area appears dark by contrast, although in fact dimly lighted through the faint general illumination of the interior of the eye by the bright image itself, and also both by a little light reflected from the face of the observer and by some light which penetrates the walls of the eyeball.

When, on the other hand, the image of the flame is larger than, and includes the field of view (see Figs. 2557, 2558 and 2562), the whole area of the pupil appears uniformly illuminated.

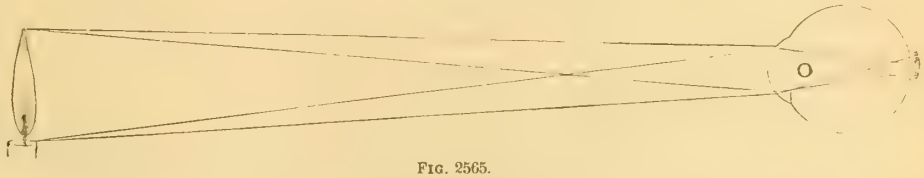

Fig. 2565.

The position of the image of the flame, relatively to the circular area of the pupil, depends upon the more or less exact centration of the illuminating and the efferent pencils; if we look through the central perforation in the mirror directly in the axis of the reflected beam, the image of the flame will be concentric with the field of view, and will be seen concentric with the pupillary area. If, now,

we change the virtual position of the flame, by slightly rotating the (plane) mirror, the retinal image will move in a direction opposite to that of the apparent motion of the flame, *i.e.*, in the direction of the rotation of the mirror—whenever the lines which define the limits of the field of view do not cross within the eye (see Fig. 2550 to 2552), and in the opposite direction when the same lines intersect in their course through the vitreous humor (see Fig. 2547). In the former of these two cases the image of the flame is seen inverted, and as a virtual image; in the latter case it is seen twice inverted, *i.e.*, erect, and as directly, as an inverted aerial image. In the direct method of examination the eye of the observer is brought very near to the observed eye, in order that the field of view, as determined by the area of the pupil, may be as large as possible (see Figs. 2550, 2551, 2553, 2554, and 2556; *cf.* Figs. 2552, 2555, 2557, and 2558); in the indirect method the observer is necessarily stationed at a much greater distance, say 20 centimetres (8 inches) or more, beyond the position of the aerial image (see Figs. 2559 to 2562).

In the direct method of examination the visibility of

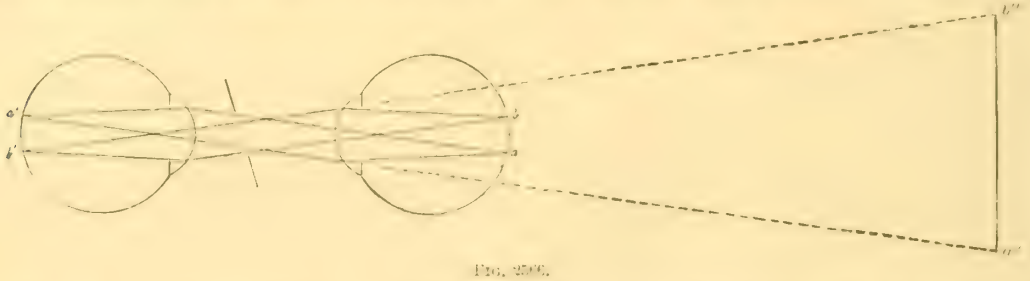

Fig. 2566.

a real image lying in front of the cornea. The apparent direction of the movements of the bright area at the fundus, when the mirror is slightly rotated, affords a ready means of determining, in any given case, whether it is seen in the erect or in the inverted image; under the incorrect and misleading name of keratoscopy, it has been made the basis of a method of estimating not only the type but also the grade of ametropia.

The lighting up of the pupil—*das Augenleuchten*—is, then, simply the effect of the strong illumination of a part of the fundus, making a bright background from which rays of light may pass out again, through the pupil, in the direction of the eye of the observer. In the living human eye the fundus is ordinarily of a vivid red color, which is the expression of the color of the blood of the choroidal circulation showing through, and more or less modified by the layer of hexagonal pigment-cells.* This color is most intense in albinos, very bright in persons of blonde complexion and light blue eyes, conspicuously darker in brunettes with deeply pigmented eyes, and least intense of all in the black races, in whom the illumination of the fundus is often so faint as to give off but little light, except from the white disk of the optic nerve, where it enters the eyeball, and from the blood-filled vessels of the retina. Under normal anatomical conditions the red color is almost wholly due to the blood

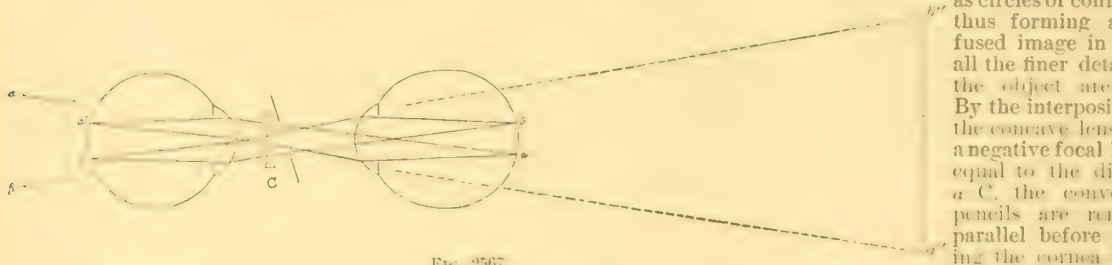

Fig. 2567.

circulating in the capillary layer of the choroid, immediately underlying the layer of hexagonal pigment-cells and completely hiding the larger and more deeply seated choroidal arteries and veins. Upon this red background, which presents a finely granulated appearance, the retinal arteries and veins show conspicuously, branching from the central artery and vein on the nearly white disk of the optic nerve.

Under appropriate conditions of refraction in the observed eye, these minuter details of the fundus may be distinctly seen, both directly, in the erect image, and in the details of the fundus is affected in different ways according as the refraction of the observed eye is normal (emmetropic) or abnormal (myopic or hypermetropic). These three principal cases must be considered in order, the observing eye being assumed to be emmetropic.

(*a*) The observed eye is emmetropic, and with relaxed accommodation (Fig. 2566). Let *a* and *b* represent the origins of two efferent pencils, at two points within the illuminated area at the fundus of the observed eye. These pencils becoming parallel after refraction at the cornea, enter the eye of the observer and are focussed at *a* and *b* upon its retina, where they form an inverted image *a' b'*, which is equal in size to *a b*. The observer looking through the pupil of the observed eye sees the portion *a b* of its illuminated fundus in the erect position, and magnified as shown by the dotted lines drawn toward *a''* and *b''*.

(*b*) The observed eye is myopic (Fig. 2567). Let *a* and *b* represent the origins of two efferent pencils, taken at the same distance apart as in Fig. 2566. These pencils, rendered convergent by refraction at the cornea, would, if continued, converge in the two foci α and β. Entering the eye of the observer stationed within this focal distance, they take on such increased convergence as would focus them at some distance in front of its retina, and, continuing on their course, they would be cut by the retina as circles of confusion, thus forming a confused image in which all the finer details of the object are lost. By the interposition of the concave lens C, of a negative focal length equal to the distance *a* C, the convergent pencils are rendered parallel before reaching the cornea of the observer's eye, so that they can be focussed accurately in the points *a'* and *b'* at its retina to form a sharply defined image. The concave lens C, placed at the anterior focus of the observed eye—*i.e.*, about thirteen millimetres in front of its cornea—is exactly the glass required to correct its myopia, and is, therefore, the equivalent of the concave spectacle-glass which will be needed in distant vision. If the lens C is held in front of the principal anterior focus of the observed eye, as is generally the case in ophthalmoscopic examinations, the focal length of the concave lens thus selected will be less than that of the required spectacle-glass, by just its distance from the anterior focus of the eye. In low grades of myopia no appreciable error can

* After death the red color of the human fundus is entirely lost.

arise from this slight variation of perhaps two or three centimetres (.8 to 1.2 inch) in the distance of the concave glass, but in the higher grades (say of 4 dioptrics = $\frac{1}{4}$, or more) the distance of the concave lens from the anterior focus must be added to its focal length, in order to insure such a degree of accuracy as this method of examination is capable of. If we wish to compute the actual grade of myopia—*i.e.*, the value of the concave lens which would correct it if it could be made an integral part of the observed eye—we must add to the focal length of the glass the distance at which it is held in front of the hypothetical position which we must assign to it, namely, the posterior nodal point, which lies 7.4 millimetres behind the cornea, or very nearly at the posterior surface of the crystalline lens.*

The details of the fundus of the myopic eye, seen through a concave lens placed behind the ophthalmoscopic mirror, appear always somewhat more magnified than in the case of the emmetropic eye (*cf.* Fig. 2566).

(*c*) The observed eye is hypermetropic, and with relaxed accommodation (Fig. 2568). Let *a* and *b* again represent the origins of two pencils, taken at the same distance apart as in Figs. 2566 and 2567. These pencils emerge from the eye divergent, as if emanating from the points α and β behind the eye; entering the eye of the observer, they are rendered convergent, but not sufficiently to focus them at its retina. The image of *a b* is therefore projected at *b′ a′* in circles of confusion. Here, however, the accommodation of the observer's eye may be brought into action, consciously or unconsciously, to focus the pencils upon its retina, and thus a distinct view of the fundus at *a b* may be obtained. Assuming that the eye of the observer remains adjusted for parallel rays, we may interpose the convex lens C, of a focal length equal to the distance α C, and thus render the divergent pencils parallel before they reach the eye. The convex lens C, placed at the anterior focus of the hypermetropic observed eye, is exactly the glass required to correct its hypermetropia; if placed at a greater distance from the eye than its anterior focus, this excess of distance must be subtracted from the focal length of the convex lens; if we wish to compute the actual grade of hypermetropia, we must subtract from the focal length of the convex lens its distance from the posterior nodal point of the observed eye.†

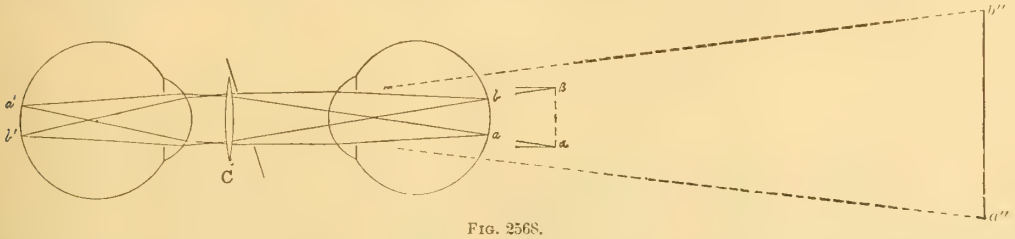

FIG. 2568.

The details of the fundus of the hypermetropic eye, seen through a convex lens placed behind the ophthalmoscopic mirror, appear always somewhat less magnified than in the case of the emmetropic eye (*cf.* Fig. 2566).

The apparent enlargement of the virtual erect image in the direct method of examination, if referred to the actual distance of the object, is the quotient of this distance, measured from the nodal point of the eye of the observer, divided by the distance of the nodal point of the same eye from its retina (about 15 millimetres, = .6 inch). These distances will be as about 4.5 : 1.5 (= 3 : 1), when the distance between the corneæ of the two eyes is taken at 1.5 centimetre (.6 inch), as in Fig. 2566, or as 6 : 1.5 (= 4 : 1), when this distance is taken equal to 3 centimetres (1.2 inch). As the effect of the concave glass (Fig. 2567) is to carry the nodal point of the observing eye somewhat farther back, the divisor is somewhat less, and the quotient proportionally greater, in the case of the myopic eye. On the other hand, the effect of the convex glass (Fig. 2568) is to advance the nodal point of the observing eye, and so to increase the divisor, and proportionally diminish the quotient, in the case of the hypermetropic eye. If, instead of referring the distance of the image to the actual distance of the object, we adopt the conventional rule of referring it to a distance of 8 Paris inches (about 21.5 centimetres), the amplification of the erect image will be represented by the ratio 21.5 : 1.5 = 14⅓ (Helmholtz).

Ametropia in the eye of the observer plays an important part in determining the visibility or invisibility of the details of the fundus in the erect image. Thus a myope who, with the unaided eye, can focus only divergent rays upon his retina, can see the fundus of only a hypermetropic eye in which the hypermetropia is equal to or exceeds the measure of his own myopia. A hypermetrope, on the other hand, can, with relaxed accommodation, obtain a clear view of the fundus of a myopic eye in which the myopia does not exceed the measure of his own hypermetropia, and, by exerting his accommodation, he may also be able to see the fundus of an emmetropic or even of a hypermetropic eye. A hypermetropic observer enjoys, therefore, a certain advantage in respect to the facility with which he can adjust his accommodation so as to see clearly under different refractive conditions of the observed eye, but he labors under a great disadvantage when he attempts to measure its refraction, and this for the reason that it is practically impossible for him either to estimate the degree to which he exerts his accommodation in the act of seeing, or to control its exercise so perfectly as to hold it with even approximate accuracy at the point required to make him virtually emmetropic. To obtain trustworthy measurements of the refraction by means of the ophthalmoscope, the hypermetropic observer should first neutralize his manifest hypermetropia—Hm (see vol. iii., p. 777)—by means of the appropriate convex glass, or else should

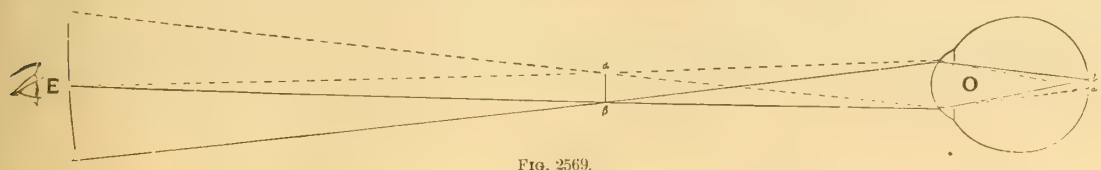

FIG. 2569.

* The use of a concave correcting glass, of a negative focal length sufficient to correct, or rather slightly to overcorrect, the sum of the myopia of the observed and the observing eye, is a part of the original invention of Helmholtz (1851).

† The principle underlying the method of measuring the refractive condition of any eye, by means of concave or convex lenses placed behind the ophthalmoscopic mirror, is clearly set forth in the first publication of Helmholtz (1851), but the practical employment of the method on an extensive scale began with E. Jaeger (1856). It was also early cultivated by Donders, and especially by Mauthner (1867). Its general adoption, as a part of the daily work of the ophthalmic practitioner, dates from the introduction, by Loring (1869), of an instrument provided with an adequate series of correcting lenses so mounted as to admit of easy and rapid changes.

subtract a quantity equal to the measure of his Hm from the value of the strongest convex glass, or add the same quantity to the value of the weakest concave glass through which he is able to see the details of the fundus distinctly. Similarly, the myopic observer should first correct his myopia by means of the neutralizing concave glass, or else should subtract a quantity equal to the measure of his myopia from the value of the weakest concave glass, or add the same quantity to the value of the strongest convex glass, through which he is able to see the details of the fundus. If the observer is astigmatic in any notable degree, he will see the fundus in the erect image under the same imperfect definition as if astigmatism were present in the observed eye. It is, therefore, essential to accuracy, in measuring the refraction by this method, that the observer correct any astigmatism that may exist in his own eye by means of the appropriate cylindrical glass (see Astigmatism, vol. i., pp. 400–405).

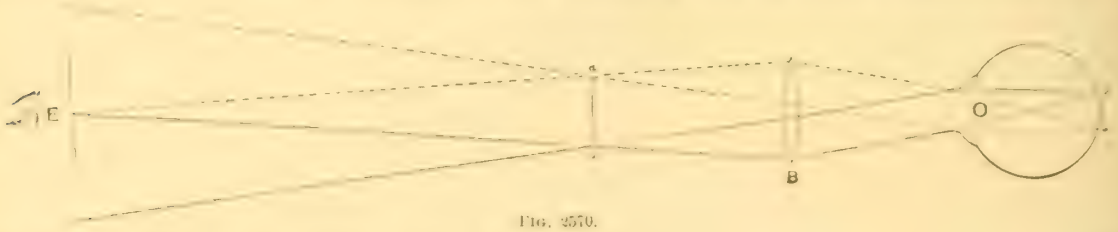

Fig. 2570.

In the indirect method of examination the observer does not look at the fundus itself, but at an inverted aërial image of the fundus. The myopic eye forms such an image at its far point (*punctum remotissimum*, *r*; see vol. i., p. 50; see, also, Myopia, vol. v.). Let *a* and *b* (Fig. 2569) represent two points taken within the illuminated area of the myopic eye, and within the field of view of the observing eye at E. Inasmuch as the points *a* and *b* lie behind the principal posterior focus of the observed eye, the pencils originating from these points emerge, respectively, from the eye as pencils of convergent rays, to be focussed at the distance of the far point *r*, where they enter into the formation of the inverted real image $\beta\,\alpha$. An observer stationed at E, not less than about twenty centimetres (8 inches) beyond $\beta\,\alpha$, may accommodate for this real image, and see all its details, sharply defined and magnified, but in the inverted position. The degree of enlargement of the inverted real image is equal to the quotient obtained by dividing its distance from the nodal point of the observed eye (*i.e.*, the distance R of its far point *r*) by the distance at which the retina of the same eye lies behind its nodal point. The higher the grade of the myopia the smaller will be the dividend R, and the larger will be the divisor. The distance at which the inverted image is formed in front of the observed eye is, therefore, inversely as the degree of the myopia; its size varies according to a somewhat higher ratio.

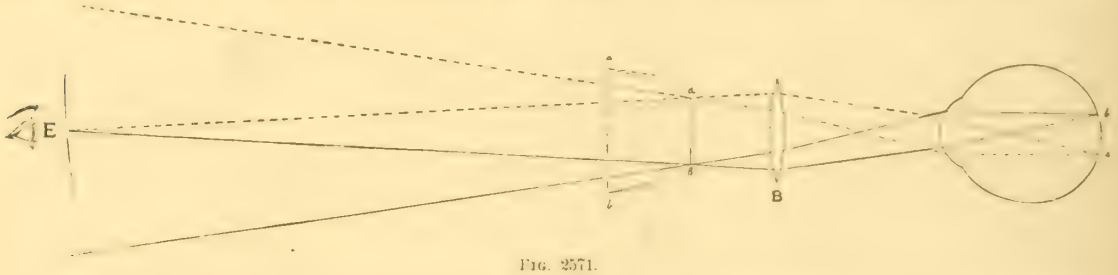

Fig. 2571.

The practical value of this method of observing the fundus of the myopic eye is greatly restricted by the fact that the field of view is at the best very small (see Fig. 2547), and that in the medium and lower grades of myopia, in which the inverted image is formed at a considerable distance from the observed eye, it becomes so contracted as to include but a very minute portion of the fundus. Moreover, the image is seen under very different degrees of amplification, according as the myopia is of a lower or a higher grade.

The indirect method is extended to the examination of all eyes, irrespective of the state of the refraction, by making both the illuminating and the efferent pencils pass through a convex lens, of from 4 to 8 centimetres (1.6 to 3.2 inches) focus, placed at about its principal focal distance in front of the nodal point of the observed eye (see Figs. 2570 to 2572; *cf.* Figs. 2559 to 2561). The efferent pencils, whether parallel (Fig. 2570), convergent (Fig. 2571), or divergent (Fig. 2572), are focussed by the convex lens either at its principal focus (in emmetropia), a little within the principal focus (in myopia), or a little beyond the principal focus (in hypermetropia). The inverted image is thus formed, in all cases, within a few centimetres of the principal focus of the convex lens, and may be viewed from the station E, taken at a distance of from 20 to 25 centimetres (8 to 10 inches) beyond the position of the principal focus.

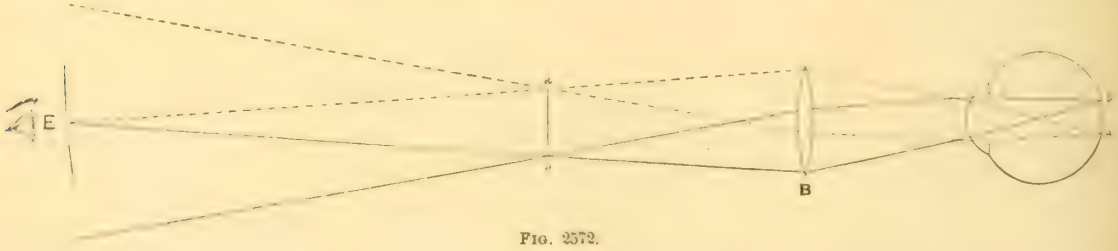

Fig. 2572.

The degree of amplification of the inverted real image, when the convex lens is placed at exactly its principal

focal distance in front of the nodal point of the observed eye (see Fig. 2573), is found by dividing the distance of the convex lens from the nodal point of the observed eye —*i.e.*, the focal length of the lens—by the distance of the nodal point of the same eye from its retina—1.5 centimetre in the emmetropic eye. With a lens of 4 centimetres (1.6 inch) focus the amplification is, therefore, $4 : 1.5 = 2.6$; with a lens of 5 centimetres (2 inches) focus, it is $5 : 1.5 = 3.3$; and with a lens of 6 centimetres (2.4 inches) focus it is $6 : 1.5 = 4$. In ametropia of the observed eye the second term in these several ratios is either greater (in myopia) or less (in hypermetropia) than the normal measure of 1.5 centimetre, so that the amplification of the inverted image is less in myopia, and greater in hypermetropia, than it is in emmetropia. This is shown in Fig. 2574, in which the three curved outlines indicate, respectively, the three different positions of the retina in hypermetropia, emmetropia, and myopia. The size of the inverted images is taken the same in all three cases, being determined by the area, at the lens, which is included between the axial rays of the two limiting pencils, but the portion of the fundus which is projected in the image is notably smaller in the hypermetropic eye, and larger in the myopic eye, than it is in the emmetropic eye. In hypermetropia the greater amplification of the image is attended with a corresponding contraction of the field of view; in myopia, on the other hand, the field of view is enlarged, but with diminished amplification of the image.

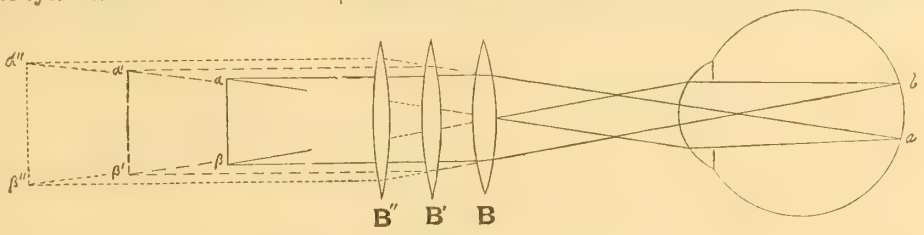

Fig. 2573.

Fig. 2574 illustrates also the effect of ametropia in the observed eye upon the position of the inverted image, according as the efferent pencils are divergent, and are focussed beyond the principal focus of the convex lens (in hypermetropia—*cf.* Fig. 2572), or are convergent, and are focussed within the principal focus of the lens (in myopia—*cf.* Fig. 2571). If we take the value of the convex lens at 20 dioptrics (5 centimetres = 2 inches focus), the place of the inverted image will be 5 centimetres (2 inches) in front of the lens in emmetropia, 7.5 centimetres (3 inches) in front of the lens in hypermetropia of 10 dioptrics ($\frac{1}{4}$), and 2.5 centimetres (1 inch) in front of the lens in myopia of 10 dioptrics ($\frac{1}{4}$). In hypermetropia of as high a grade as 20 dioptrics ($\frac{1}{2}$)—*e.g.*, in an originally strongly hypermetropic eye from which the crystalline lens has been removed (see vol. iii., p. 782), the image will be formed at a distance of 10 centimetres (4 inches) in front of the convex lens of 5 centimetres focus, in which case it may be found convenient to use a somewhat stronger lens (say of 25 dioptrics—4 centimetres = 1.6 inch focus); in grades of hypermetropia not exceeding 10 dioptrics ($\frac{1}{4}$) it is sufficient to take the station of the observer a little farther from the lens.

In myopia of as high a grade as 20 dioptrics ($\frac{1}{2}$) the image will be formed at a distance of only 5 centimetres (2 inches) in front of the nodal point of the eye—*i.e.*, at the assumed distance of the convex lens, so that the lens must be held at less than its focal distance from the eye in order to enable it to take part in the formation of the image; but with this change in the position of the lens the extent of the field of view begins to be limited by the pupillary opening (see Fig. 2560), and, with an undilated pupil, it may become so contracted as to render the examination difficult. In the highest grades of myopia a modification of the indirect method of examination is, therefore, to be preferred.

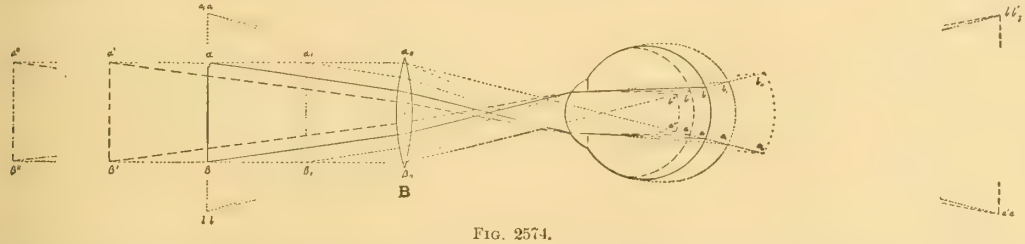

Fig. 2574.

Fig. 2575 shows a greatly elongated eye, representing a myopia of about 20 dioptrics ($\frac{1}{2}$), and, therefore, forming an inverted image of its fundus at a distance of about 5 centimetres (2 inches) in front of its nodal point (*cf.* Fig. 2569). A convex lens of rather large diameter, and of somewhat less than 20 dioptrics power (> 5 centimetres, > 2 inches focus), is held at about its principal focal distance in front of the cornea of the observed eye, and, therefore, at a distance somewhat greater than that of the inverted image. The observer, at E, views the image through the convex lens, and consequently sees it magnified by the lens. In this position of the convex lens neither the intensity of the illumination nor the amplitude of the field of view is materially influenced by the size of the pupil (*cf.* Fig. 2562), but both are determined by the size and the power of the lens. A large lens, of a focal length somewhat greater than the distance of the image from the nodal point of the observed eye, and held at about its principal focal distance in front of the cornea, gives an ample field of view conjoined with notable enlargement of the inverted image. If the lens is moved nearer to the observed eye

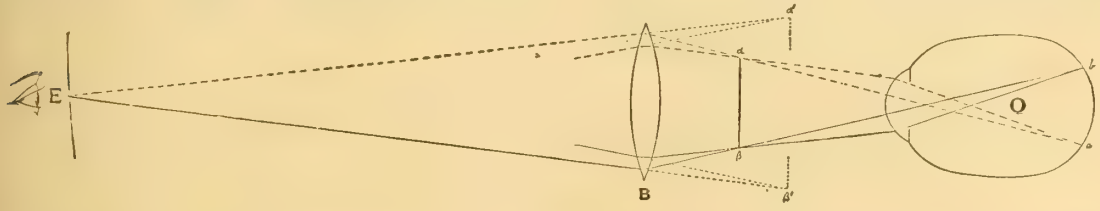

Fig. 2575.

—*i. e.*, nearer to the place of the image—the field of view will become more extensive and the amplification less; if, on the other hand, the lens is moved farther away from the eye, the field of view will be less extensive and the amplification greater. A convex lens of about 10 dioptries power (10 centimetres = 4 inches focus), held from 10 to 12.5 centimetres (4 to 5 inches) in front of the observed eye, is generally used in this method of examination; the field of view is larger than in the case of an excessively myopic eye when examined by the direct method, and the amplification is much greater than when the inverted image is formed by the intervention of the convex lens in the ordinary method of indirect examination.

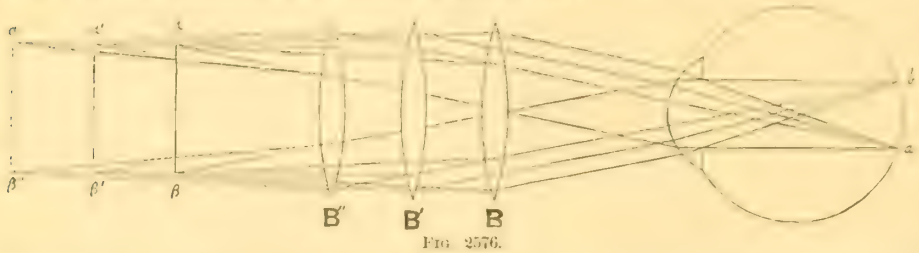

Fig. 2576.

In emmetropia of the observed eye the efferent pencils, of parallel rays, are focussed by the convex lens at its principal focal distance irrespective of the distance at which the lens is held in front of the eye. The amplification of the image remains also constant for any particular lens, whether the distance of the lens from the eye be taken greater or less than its principal focal length (see Fig. 2576). Only the conditions of illumination and the amplitude of the field of view are affected by the change in the position of the lens (*cf.* Figs. 2559 to 2562).

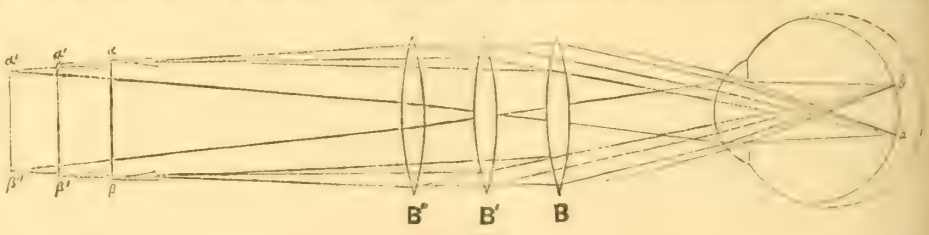

Fig. 2577.

In ametropia, on the other hand, any change in the distance of the convex lens from the observed eye is attended, also, with some change both in the distance at which the inverted image is formed in front of the lens and in the amplification of the image. In hypermetropia (see Fig. 2577), if we move the lens farther away from the eye, the movement of the image away from the eye will be somewhat less than the movement of the lens, and, at the same time, the amplification of the image will be somewhat diminished. Conversely, if we move the lens nearer to the eye, the movement of the image toward the eye will be somewhat less than the movement of the lens, and, at the same time, the amplification of the image will be somewhat increased. In myopia, on the other hand (see Fig. 2578), any increase in the distance of the convex lens from the eye is attended with a somewhat less extensive movement of the image in the same direction, but the amplification of the image is somewhat increased. Conversely, any movement of the convex lens toward the eye is attended with a somewhat less extensive movement of the image in the same direction, and the amplification of the image is somewhat diminished.

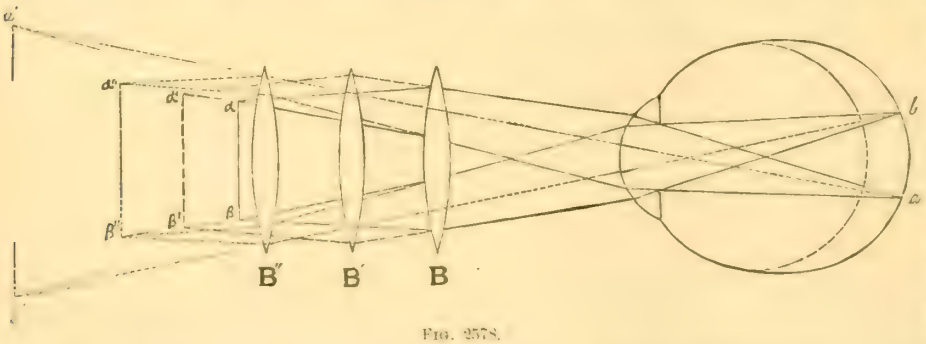

Fig. 2578.

This change in the amplification of the inverted image in ametropia gives rise to a characteristic phenomenon in the higher grades of astigmatism, namely, a change in the apparent form of the disk of the optic nerve, according as the convex lens is held at a greater or less distance in front of the observed eye. In mixed astigmatism (Am + Ah, see vol. i., p. 401) the eye is virtually myopic in the principal meridian of greatest refraction (Mo), and hypermetropic in the principal meridian at right angles to this meridian. It follows that, in moving the convex lens farther away from the eye, the amplification of the image increases in the direction of the ocular meridian of greatest refraction, and diminishes in the direction of the meridian of least refraction, so that the optic disk, which is, as a rule, actually circular, appears oval. If, now, we move the convex lens nearer to the observed eye, the amplification will diminish in the direction of the meridian of greatest refraction, and will increase in the direction of the meridian of least refraction, until, at a certain distance from the eye, the two diameters become equal; on passing this point the inequality reappears, but with the direction of the long and short diameters of the oval reversed. In compound hypermetropic astigmatism (H + Ah), simple hypermetropic astigmatism (Ah), simple myopic astigmatism (Am), and compound myopic astigmatism (M + Am), the change in the apparent form of the disk, which depends wholly on the degree of astigmatism, is precisely the same as in mixed astigmatism; only the distance at which the lens must be held from the eye, in order to permit the disk to be seen under its normal circular form, is different for each particular case.

This change in the apparent form of the inverted image of the optic disk in astigmatism is necessarily attended with some indistinctness of outline, but this practically adds to, rather than detracts from, the conspicuousness of the phenomenon. In the case of the retinal vessels the definition varies greatly, according as they happen to lie approximately in the direction of one or the other of the diameters of the oval. Both the distortion of the inverted image of the disk, and the inequality in the definition of the vessels which lie in the direction of the two

principal meridians, may be made to disappear by the very simple expedient of rendering the convex lens itself astigmatic by holding it at an angle to the visual axis, which angle must be greater or less according to the grade of astigmatism to be overcome. Thus we have, in the indirect method of examination, a ready means not only of detecting the higher grades of astigmatism and of estimating the direction of the meridians of greatest and least refraction, but also of provisionally correcting the astigmatism for the purposes of observation.

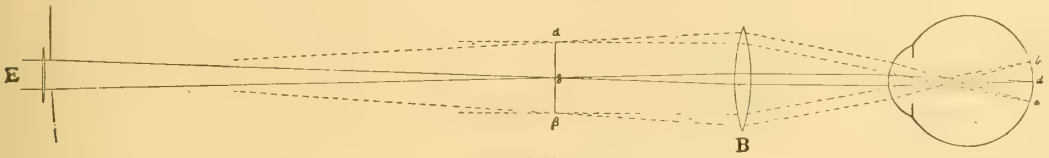

Fig. 2579.

The ample field of view, conjoined with as intense an illumination as can be utilized, the convenient degree of enlargement of the retinal picture (usually a little more than threefold), the fact that the conditions of visibility of the fundus are not materially affected by hypermetropia, or by any but the highest grades of myopia, and the facility with which the disturbing influence of astigmatism may be annulled by giving an oblique position to the lens, all combine to render the indirect method particularly available whenever we wish to obtain a general view of a large area of the fundus. On the other hand, for the examination of the fundus in detail, and under a greater magnifying power (about fourteenfold when the virtual image is referred to the distance of eight Paris inches, at which we ordinarily view the inverted real image), and especially in measuring the refraction of the observed eye, the direct method offers advantages which are entirely its own. The two methods are, therefore, to be cultivated side by side, each supplementing the other, and the two together affording the means of studying the fundus with a thoroughness not so perfectly attainable by the use of either method alone.

In order to be able to use both methods equally well, and so to obtain from each the best service of which it is capable, it is of the first importance that the observer eliminate all complications arising from the unregulated exercise of his own accommodation. This most important end can be attained only by training ourselves to make all examinations, as well by the indirect as by the direct method, under the uniform condition of complete accommodative relaxation. And here the learner has, first of all, to suppress an instinctive tendency to accommodate for the short distance at which he knows that the object, or its image, actually lies. Hence, in practising the direct method, the learner should be made to feel that he must look not so much into the observed eye as through it, as if viewing an object lying far away from him. If himself myopic, he should accustom himself always to use the weakest concave correcting glass, and if hypermetropic, to use the strongest convex correcting glass through which he can obtain a distinct view of the details of the fundus; if emmetropic, he should train himself to observe the fundus of an emmetropic eye without a correcting glass, and in examining a myopic or a hypermetropic eye he should learn to select the particular concave or convex correcting glass which suffices exactly to overcome its myopia or hypermetropia. In practising the indirect method the learner should also acquire the habit of viewing the inverted image with relaxed accommodation, which he will accomplish, if emmetropic, by looking through a convex lens of about 5 dioptrics power (20 centimetres = 8 inches focus) placed immediately behind the hole in the ophthalmoscopic mirror; or, if hypermetropic, by substituting for this lens such other lens, of shorter focus, as shall, in addition, correct his manifest hypermetropia (Hm, see vol. iii., p. 777); if myopic, he should similarly employ the convex or concave lens which accurately adjusts his own far point (r) for the distance of 20 centimetres (8 inches); and only in the particular case in which his far point lies at this distance ($M = 5$ dioptrics $= \frac{1}{r}$) should he practise the indirect method without a correcting glass.

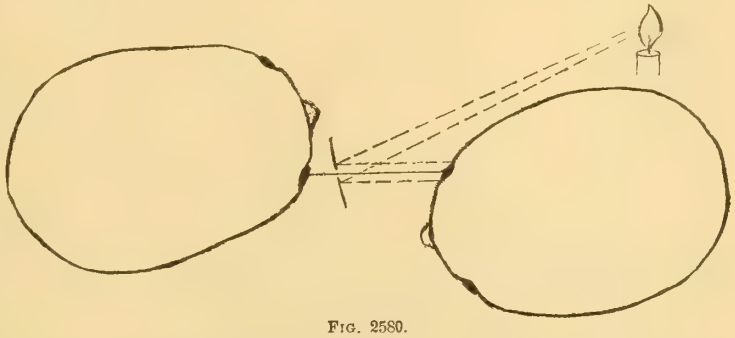

Fig. 2580.

The use of a convex correcting glass in the indirect method of examination is shown in Fig. 2579; for the use of a concave or convex correcting glass in the direct method of examination see Figs. 2567 and 2568.

A fairly large pupil is always desirable in ophthalmoscopic examination, and in the use of the direct method it is often indispensable. Nevertheless, it is not always advisable to make use of a mydriatic. As the pupils contract both under the stimulus of strong light and in connection with the exercise of the accommodation, it is best to conduct all ophthalmoscopic examinations in a completely darkened room of considerable size, and preferably with walls of a dark color. The general darkness

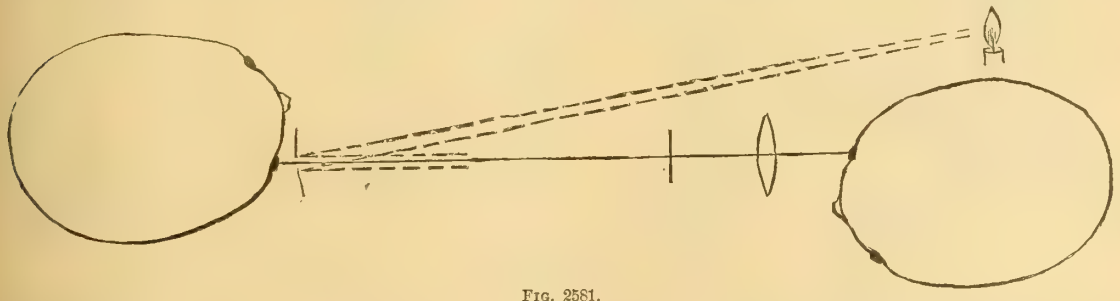

Fig. 2581.

of the room is favorable to the dilatation of the pupils, and the consciousness that he is in a room of some size makes it easier for the patient to relax his accommodation when he is asked to direct his gaze toward some pretty large and faintly lighted object upon the opposite wall. By observing these precautions the causes which incite to contraction of the pupils are, in a great measure, eliminated, with the single exception of the direct influence of the light reflected into the eye by the mirror. In the great majority of cases the light of a student's lamp, reflected from the ordinary concave mirror of silvered glass, excites but a

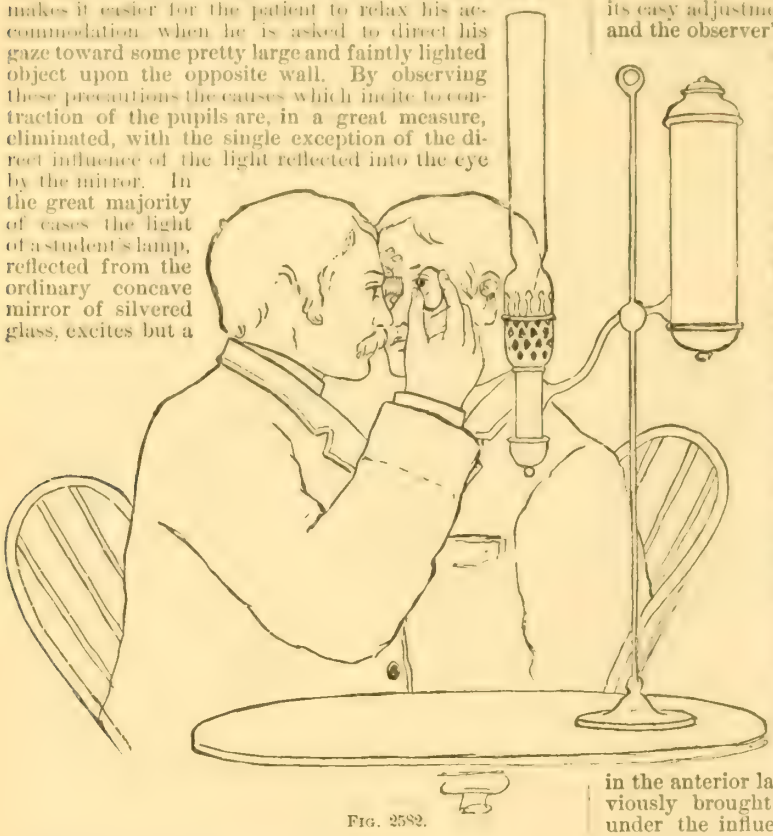

Fig. 2582.

moderate degree of contraction, and, in fact, most of the necessary examinations by the direct method may be satisfactorily made by the aid of this mirror without having recourse to artificial dilatation of the pupil. In searching for minute changes in the region of the macula lutea it is, however, generally advisable to make use of a weak mydriatic, such as cocaine, homatropine, or perhaps a very weak solution of atropia. If, for any reason, it is judged inexpedient to instil any solution into the eye, the plane mirror of Helmholtz, made of several layers of unsilvered glass, may sometimes be made to render excellent service.

In order to permit the patient to direct his gaze upon a somewhat distant large object, it is important that his view, with the eye not under examination, be not cut off by the head of the observer. Hence it is a very useful rule, of general application, that the observer accustom himself always to use his right eye in examining the right, and his left in examining the left eye (see Figs. 2580 and 2581).

The ophthalmoscopic armamentarium, in its simplest effective form, includes (1) a perforated concave mirror, of about 33 millimetres (1.3 inch) diameter, and 22.5 centimetres (9 inches) focus, mounted on a handle of about 13 centimetres (5 inches) length, and fitted with a rotating disk or other simple mechanism by which the required concave or convex correcting glass may be easily brought into place behind the hole in the mirror; (2) a convex lens, of a diameter of about 4 centimetres (1.6 inch) and a focal length of 5 or 6 centimetres (2 to 2.4 inches); and (3) a good lamp, which should be so mounted as to admit of its easy adjustment to about the height of the observed and the observer's eye. This simple apparatus, used in a well darkened room, affords the means of thoroughly exploring the eye in its entire depth, from the anterior epithelium of the cornea back to the retina, or, in certain pathological conditions, to the choroid or even to the sclera.

If we place the lamp a little in front of the plane of the patient's eyes, and concentrate a cone of light upon the cornea by means of the convex lens (Fig. 2582), the conditions of illumination are very favorable to the detection and observation of any slight irregularities or opacities in the cornea, whether superficially or more deeply seated, and also of the finely punctate deposits which often occur in or upon the lining membrane of the cornea (membrane of Descemet). If we change very slightly the position of the lens, so that the cone of light shall fall upon the iris, we are enabled to note slight changes in the texture of this organ, and also any irregularities in the contour and pigmentation of the pupillary margin. By concentrating the light upon the region of the pupil, we are similarly enabled to detect thin deposits of lymph obscuring the anterior capsule of the crystalline lens in the pupillary field, specks of brown pigment detached from the posterior surface of the iris and adherent to the lens-capsule, and also such opacities as have their seat in the capsule or in the anterior layers of the crystalline. If we have previously brought the eye under the influence of a mydriatic, we are enabled to detect and carefully study any adhesions (synechiæ) which may have been formed between any part of the pupillary border and the lens-capsule, whether these be recent or of indefinitely long standing. If the pupil is widely dilated by the

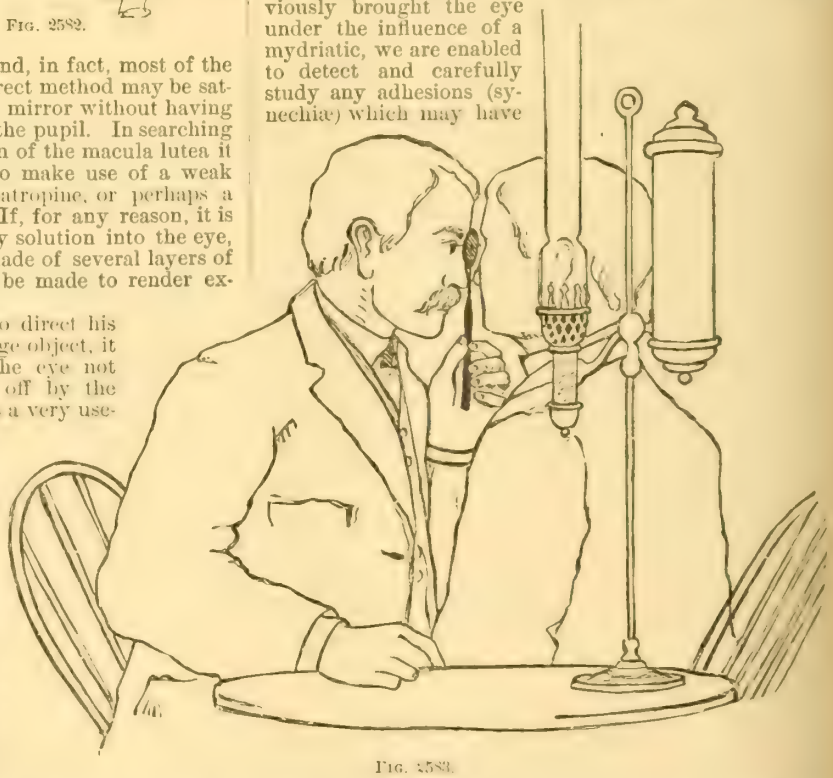

Fig. 2583.

mydriatic, we may look deeply into or through the crystalline lens (*cf.* Fig. 2542) and thus detect and observe the various forms of opacity incident to different types of cataract, or we may even look so deeply into the vitreous as to detect a mass of effused blood or lymph, or a very prominent tumor growing from the fundus. In many cases it is desirable to make use of a magnifying-glass in connection with this lateral or oblique focal illumination, for which purpose there is nothing better than an ordinary doublet of about 3.5 centimetres (1.4 inch) focal length. By the method of lateral illumination all objects are seen by the light which they reflect from their surface, and, therefore, in their actual color.

In using the mirror, the lamp is placed a little behind the plane of the patient's face, and, preferably, on the same side as the eye to be examined. Having placed a convex glass of about 20 centimetres (8 inches) focus behind the hole in the mirror, we throw the light upon the eye from a distance somewhat less than the focal length of the lens. Looking through the mirror, we see the field of the pupil brightly illuminated, and of a vivid red color, whenever the media are of normal transparency and the fundus is of its normal color.

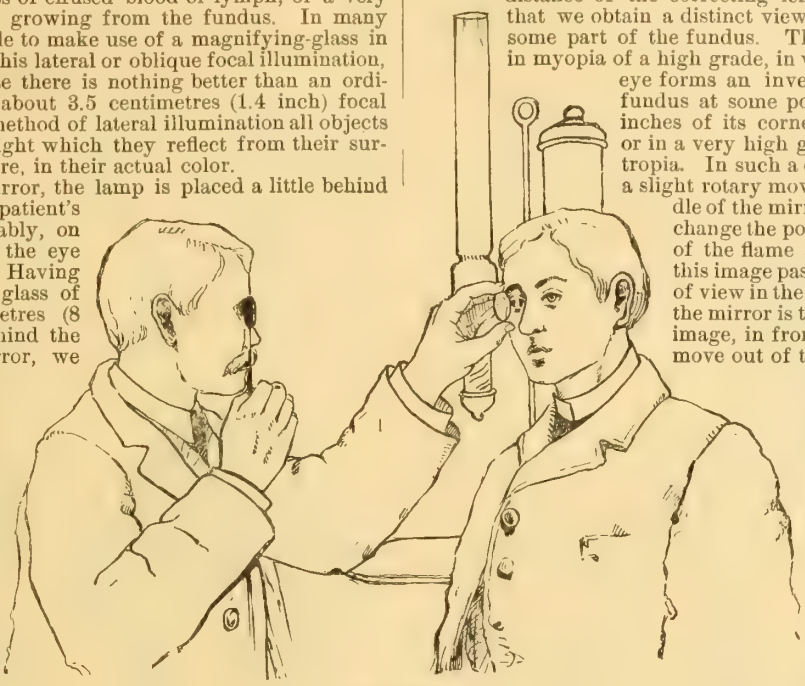

Fig. 2584.

In the presence of diffuse clouding of the cornea or crystalline lens, or a turbid condition of the aqueous or vitreous humor, the red color of the pupil may appear conspicuously dulled, or may not be seen at all. A circumscribed opacity, on the other hand, whether in the cornea, on the anterior lens-capsule, or in the substance of the crystalline, appears black against the red background of the fundus. Motes and shreds in the vitreous appear, also, as a rule, under the form of black bodies, intercepting the red light from the fundus, but in rare instances, as in the case of the crystalline plates of cholesterine, they may reflect so much light as to sparkle brilliantly (*synchysis scintillans*). If a fixed opacity has its seat at or very near the centre of motion of the eyeball (about fourteen millimetres behind the vertex of the cornea), it will undergo little or no change of actual position when the observed eye is turned in different directions; if in front of this centre, it will move in the direction in which the eye is turned, and if behind the centre, it will move in the opposite direction. The greater the distance at which the body lies in front of or behind the centre, the greater will be the range of its excursions. Thus a spot in the cornea will move through a larger arc than an opacity at the depth of the anterior lens-capsule, and this, in turn, will move through a larger arc than one situated at or near the posterior capsule. Inasmuch as the pupil and the anterior lens-capsule lie at the same depth within the eye, an opacity situated at the front of the lens maintains a nearly constant position when referred to the bright field of the pupil, while a spot on the cornea, or in the deeper layers of the lens, makes conspicuous excursions across this field; in the one case in the direction in which the eye is turned, in the other case in the opposite direction. Still another point to which the motion of a visible body, lying deeply within the eyeball, may be referred is the bright image of the light reflected from the front of the cornea. In whatever direction the observed eye is turned, this bright reflex is always seen at the point on the cornea which lies nearest to the eye of the observer; it, therefore, offers an approximately fixed point, to which the movements of a body lying at any depth in the eye may be referred with a very considerable degree of accuracy.

Still holding the mirror at a little less than the focal distance of the correcting lens it may happen that we obtain a distinct view of the details of some part of the fundus. This can occur only in myopia of a high grade, in which the unaided eye forms an inverted image of its fundus at some point within a few inches of its cornea (*cf.* Fig. 2569), or in a very high grade of hypermetropia. In such a case we may make a slight rotary movement of the handle of the mirror, and so slightly change the position of the image of the flame at the fundus; as this image passes out of the field of view in the direction in which the mirror is turned, its inverted image, in front of the eye, will move out of the field in the opposite direction; in hypermetropia the movement of the virtual image of the flame will be in the direction in which the mirror is rotated. If, while looking at the inverted image of the fundus, we bring the mirror nearer to the eye, we presently reach a point at which the details of the picture are lost. We next advance the mirror to the usual position for the observation of the fundus in the erect image, namely, within 5 centimetres (2 inches) of the cornea of the observed eye (see Fig. 2583). At this short distance the field of view is much enlarged (see Figs. 2550, 2551, 2553, and 2554; *cf.* Fig. 2555), and the conditions are favorable to the detection and observation of fixed or floating opacities lying deep in the vitreous, as well as for the observation of a detached retina, or a tumor growing from the fundus. It may also happen that on approaching the observed eye the details of the fundus have become visible, indicating the presence of hypermetropia of a grade

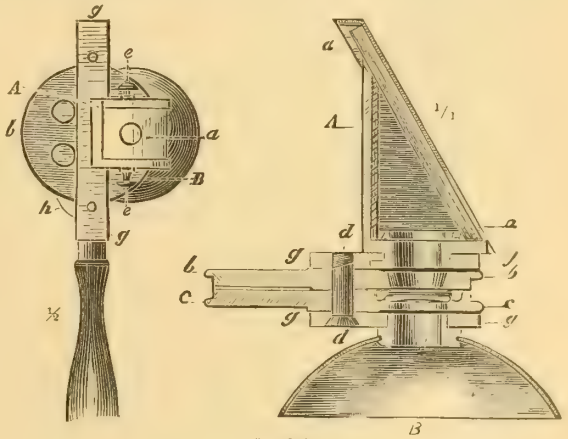

Fig. 2585.

in excess of the power of the convex glass behind the mirror. In such a case we may proceed at once to observe the degree of hypermetropia, by bringing progressively stronger convex glasses into position behind the mirror, until the measure of the hypermetropia is reached.

If, on approaching the eye the details of the fundus are not seen, or are seen but indistinctly, through the convex glass of five dioptrics, we may exchange it for successively weaker convex glasses, or for concave glasses of progressively greater power, until, by noting the character and power of the glass which first affords a perfectly distinct view, we have obtained a definite measurement of the refraction. If, in the course of the successive observations with glasses of different power, we at first get a distinct view of only such of the retinal vessels as correspond in direction to one of the ocular meridians, and with some other glass we obtain an equally distinct view of the vessels corresponding in direction to the meridian at right angles to the former, we have both established the presence of regular astigmatism and obtained the data for the determination of its type and the measurement of its grade. If, as sometimes happens, we see the same vessels, or parts of vessels, under different degrees of definition, according as we view them through different parts of the cornea, we have to do with a case of irregular refraction (irregular astigmatism) dependent probably upon some irregularity in the contour of the cornea. In such a case the bright reflex from the cornea may present conspicuous variations in size and in shape, dependent on differences in the contour of the reflecting surface. In keratoconus (conical cornea), of even low grades, the distortion of the retinal picture and the changes in the form and size of the corneal reflex are very characteristic.

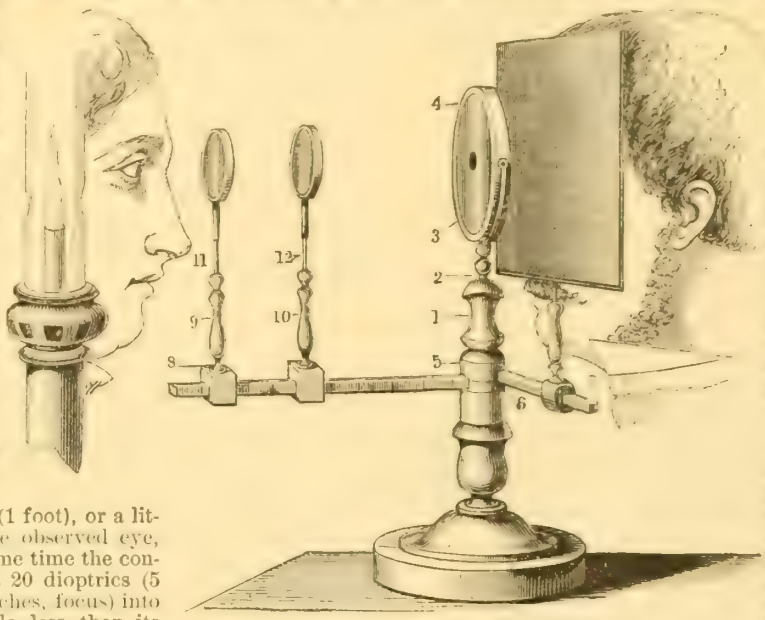

Fig. 2586.

We may now withdraw the mirror to a distance of 30 centimetres (1 foot), or a little more, from the observed eye, bringing at the same time the convex lens of about 20 dioptrics (5 centimetres = 2 inches, focus) into position at a little less than its principal focal distance in front of the cornea (see Fig. 2584). At this stage the beginner may encounter a very troublesome obstacle to his view of the interior of the eye from the bright reflex images of the flame or mirror formed by the two surfaces of the convex lens, the one virtual, and lying behind the lens, the other real, and lying in front of the lens. When the lens is held exactly concentric with, and at right angles to, a line connecting the pupils of the observing and the observed eye, the two reflex images lie also in this line, and may thus completely cut off the view into the eye. Both images are, however, easily got out of the way, either by moving the convex lens into a position somewhat eccentric to the line of sight, or by slightly rotating the lens, so as to separate the two images and displace them in opposite directions. The convex lens, held at somewhat less than its focal distance in front of the eye, considerably magnifies a spot in the cornea, or in the field of the pupil, as seen from behind the hole in the mirror, and the conditions are favorable, generally, to the inspection of these parts of the eye. We may next turn our attention to the details of the fundus, as seen in the inverted image, at about the position of the anterior principal focus of the convex lens, looking at it, for reasons already given, through a convex glass of about 5 dioptrics (8 inches focus), placed behind the hole in the mirror. Having displaced the two reflex images formed by the convex lens by moving it a little to one side or by giving it a position not exactly at right angles to the line of sight, we may encounter a further obstacle to a view of the fundus from the reflex image formed by the anterior surface of the cornea. This will, however, give no trouble, except in the particular case where the vertex of the cornea of the observed eye is directed exactly toward the hole in the mirror, a slight deviation of the gaze in any direction sufficing to displace the bright reflex from the central region of the pupil. Inasmuch as the inspection of the region of the macula involves the turning of the observed eye in the exact direction of the eye of the observer, the indirect method is not favorable to obtaining a good view of this part of the fundus. Nevertheless, we may often succeed in eliminating much of the disturbance from the reflex image by making lateral movements of the convex lens in different directions.*

It happens not infrequently that in moving the convex lens in a lateral direction a loop of a retinal blood-vessel appears to change conspicuously in form. This is an effect of parallax, and is dependent on the fact that, by the lateral movement of the lens, the line of sight is considerably deflected, so that we really look at the vessel as from a different point of view. A loop of a retinal artery or vein, lying in a plane perpendicular to the general surface of the fundus, may appear as a straight line when viewed from a point directly in front, but will show some degree of curvature when viewed from either side. Hence, by making considerable excursions with the lens, a seemingly straight portion of a blood-vessel may sometimes be made apparently to bend to the one side or the other, or perhaps to both sides in succession; the amount of apparent bending will depend upon the actual height of the loop and the extent of the lateral excursions of the lens.

For the inspection of the rest of the fundus, including the disk of the optic nerve, the conditions are altogether favorable. To see the optic disk, which is situated a little to the nasal side of the posterior pole of the eye, the patient must turn his eye a little in the same direction, which he will most easily and surely accomplish by looking a little to the temporal side with the eye not under examination. To obtain a view of the peripheral regions of the fundus, the patient must turn his eye in the direction of the part to be examined, the details of which, as seen in the inverted image, will appear to move in the same direction. The changes in the apparent form of the inverted image of the disk in astigmatism have been already described (see p. 3085).

The ophthalmoscopic mirror may be used at a very long range, say of about one metre, in the investigation of the refractive condition of the eye. Couper (1872) has

* The geometrical axis of the cornea does not exactly coincide with the line of sight, the latter cutting the cornea a little to the nasal side of its vertex, the former cutting the retina a little to the nasal side of the macula. Hence the corneal reflex does not, as a rule, exactly cover the image of the macula. The angle which the axes of the cornea makes to the line of sight is known as the angle α (Donders): it is greatest in hypermetropic eyes, and least, sometimes even negative, in myopic eyes.

recommended the use of a special concave mirror, of somewhat less than one metre focal length, which gives a brilliant illumination at a long range. If the observed eye is myopic in any degree exceeding one dioptric ($\frac{1}{40}$), it forms an inverted image of its illuminated fundus at one metre or less in front of its nodal point, and the details of some portion of this image may be seen from behind the hole in the mirror. As at this distance the field is extremely small (*cf.* Fig. 2569), it may happen that at the first glance nothing but the red color of the fundus is distinguishable, so that the patient may have to turn his eye slightly in different directions before one of the retinal vessels comes into view. If the observer looks through a convex glass, of say 5 dioptrics (8 inches focus), placed behind the hole in the mirror, he may easily calculate the distance of the image from the observed eye, from the distance at which he sees the vessel sharply defined. If astigmatism is present, such of the retinal vessels as are visible will be seen to lie in a meridian corresponding to one or the other of the principal meridians of the (astigmatic) eye.[1]

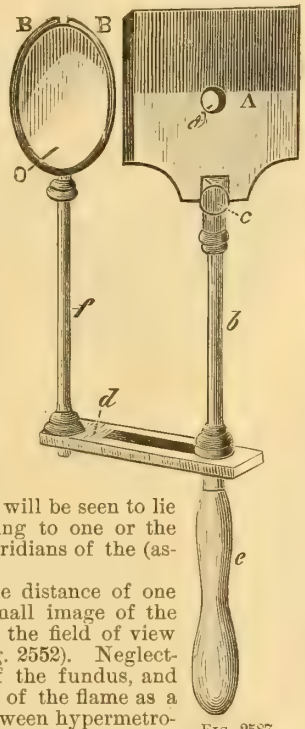

Fig. 2587.

A plane mirror, at the distance of one metre, gives but a very small image of the flame at the fundus, and the field of view is also very small (*cf.* Fig. 2552). Neglecting entirely the details of the fundus, and regarding only the image of the flame as a whole, the distinction between hypermetropia and myopia may be made by simply observing the direction in which the image moves when the direction of the illuminating beam is changed by slightly rotating the mirror. This test turns on the fact that in hypermetropia the image which we see is virtual, and is situated behind the observed eye, while in myopia it is a real image, and is situated in front of the observed eye. Hence, in hypermetropia the image is seen to move into, across, and out of the field of view in the direction in which the (plane) mirror is rotated; in myopia the movement is in the opposite direction. As the details of the image are not regarded in this test, no correcting glass is used behind the mirror, unless it be

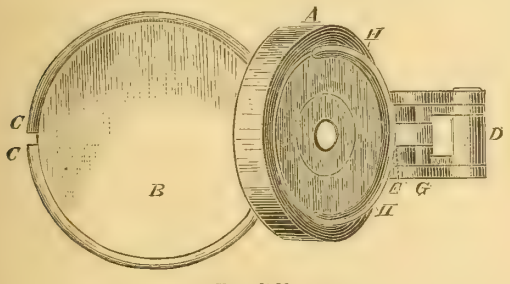

Fig. 2588.

needed to correct a high grade of ametropia in the eye of the observer. In this test it amounts practically to the same thing whether we speak of the movements of the bright image, or of the borders of the surrounding dark area against which it is seen projected, and it so happens that the attention of writers who have cultivated this method has been directed rather to the movements of the dark border (shadow) than to the image of the illuminating flame. Hence the name, *shadow-test*, by which this method is commonly designated. Under the mistaken impression that the so-called shadow is in some way produced by the cornea, the incorrect and misleading name *keratoscopy* has been widely adopted; *retinoscopy* is scarcely more appropriate. Perhaps the least objectionable name that has been suggested is *koroscopy*—from κόρη, pupil (Landolt); the word pupilloscopy, used also by Landolt, is a mongrel.[2]

As a rule, an eye under ophthalmoscopic examination relaxes its accommodation, and this is especially true in hypermetropia of the higher grades, in which the latent hypermetropia (Hl), which evades detection by the usual subjective tests, is generally very large. Ophthalmoscopic measurements of hypermetropia are, therefore, often much more accurate than those made with the aid of test-letters, unless the latter are made under complete paralysis of the accommodation. In the case of certain careless or obstinate patients, of some illiterate persons, and especially of young children, the ophthalmoscope is indispensable in the diagnosis of ametropia in all its forms.

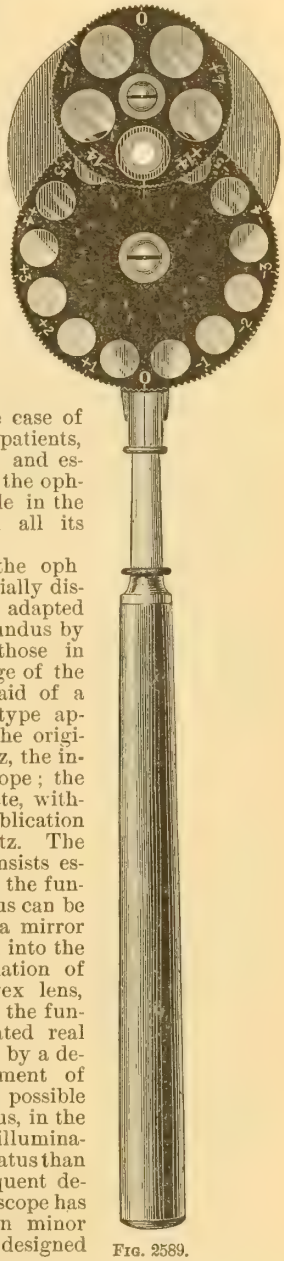

Fig. 2589.

Two principal types of the ophthalmoscope are to be especially distinguished, namely, those adapted to the examination of the fundus by the direct method, and those in which an inverted real image of the fundus is formed by the aid of a convex lens. The former type appears, fully developed, in the original instrument of Helmholtz, the inventor of the ophthalmoscope; the latter was perfected by Ruete, within the year following the publication of the discovery of Helmholtz. The invention of Helmholtz consists essentially in the discovery of the fundamental fact that the fundus can be seen by looking through a mirror from which light is reflected into the eye; Ruete, by the combination of concave mirror and convex lens, found the means of viewing the fundus in a strongly illuminated real image. Helmholtz, in turn, by a development of the experiment of Brücke, showed that it was possible to see the details of the fundus, in the inverted image, by direct illumination, and with no other apparatus than a convex lens. The subsequent development of the ophthalmoscope has been confined to changes in minor details, and to modifications designed to facilitate certain special uses.

The experiment of Brücke (see Fig. 2548) solved the problem of the illumination of the fundus by direct light; the addition, by Helmholtz, of a convex lens (see Figs. 2559 to 2561) made it possible also to see the details of the fundus in the inverted image; by the addition of a refracting prism to the lamp (see Fig. 2549) the same principle is extended to the examination of the fundus in the erect image.

It is entirely practicable to illuminate the fundus by direct light, and view the image, whether erect or inverted, in the mirror. Thus in the arrangement shown

in Fig. 2550 it is possible, though generally less convenient to place the lamp at L, and to view the image, by reflection, from L; using an electric lamp at L or at L', it is quite practicable for two observers, stationed at L' and L, to view the fundus of O at the same time. Demonstrating ophthalmoscopes for two observers are based on this principle.*

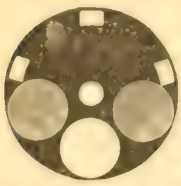

Fig. 2590.

Fig. 2591.

Again, the efferent pencils emanating from different parts of the illuminated area at the fundus may be divided just behind the mirror, so that each half, after two reflections, shall enter the corresponding eye of the observer. The binocular ophthalmoscope, like the binocular microscope, gives some degree of stereoscopic effect.†

Fixed ophthalmoscopes, as distinguished from ophthalmoscopes in which the mirror and the convex lens are held by the two hands of the observer, have been devised in considerable number; they have been used in measuring the details of the fundus, in making drawings of the fundus in normal and pathological states, and, especially, in demonstrating the ophthalmoscopic picture to a number of persons in succession.‡ Their prototype is to be found in the original form of the ophthalmoscope of Ruete. The camera lucida may be used with any fixed ophthalmoscope.*

Ophthalmoscopes have also been constructed with a combination of mirrors, by means of which an observer may, with one eye, see the fundus of his other eye; by another arrangement of mirrors an image of the optic disk is formed at the macula of the same eye. These are curiosities of ophthalmoscopy.‡

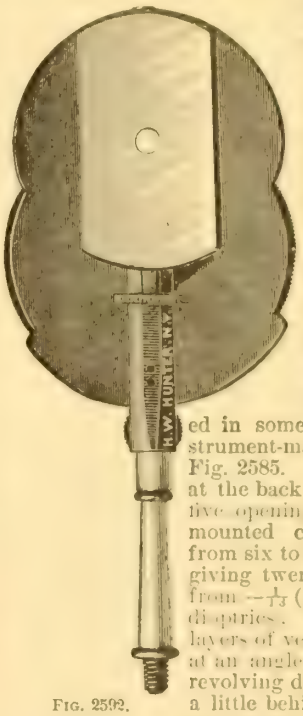

Fig. 2592.

The ophthalmoscopes which have won a permanent place in the armamentarium of the ophthalmic practitioner are all based directly upon the reflecting ophthalmoscopes of Helmholtz and Ruete. A few typical forms must be briefly noticed.

The ophthalmoscope of Helmholtz (1851), perfected in some of its details by the instrument-maker Rekoss, is shown in Fig. 2585. The two revolving disks, at the back of the mirror, have each five openings, in four of which are mounted concave glasses, varying from six to thirteen inches focus, thus giving twenty combinations varying from $-\frac{1}{6}$ (−3 dioptrics) to −13 (−13 dioptries). The mirror, made of three layers of very thin plate glass, is set at an angle of 56° to the plane of the revolving disks. The lamp is placed a little behind the plane of the observer's pupil, necessitating the use of a screen, to shade the observed eye from the direct light. The purpose of the concave glasses, in the two disks, is to permit the details of the fundus to be distinguished notwithstanding the presence of myopia of the observing or of the observed eye, or of both.*

The ophthalmoscope of Ruete (1852) consists of a per-

* In every reflecting ophthalmoscope there are two points of view at which the eye of an observer may be stationed, and receive rays of light from the illuminated fundus, namely, the usual and most favorable position, which is immediately behind the mirror, and a less favorable position close by the side of the lamp. The use of an electric lamp makes it possible to see the details of the fundus from a station in its immediate vicinity, whenever the rays reflected from the mirror are parallel or divergent, as is the case when a plane or a slightly convex mirror is used; the same condition is realized also in the use of the concave mirror, whenever the distance of the mirror from the inverted image is less than its focal length. With a concave mirror of a focal length less than its distance from the place of the inverted image, a twice inverted (*i.e.*, erect) image of the fundus may be formed at some point between the mirror and the lamp. A third point of view may be obtained by deflecting a part of the efferent rays at some point between the observed eye and the mirror. This is effected in the "ghost" ophthalmoscope of Laurence (Klinische Monatsblätter für Augenheilkunde, S. 534, 1863): by interposing a sheet of polished transparent glass, set at an angle of about 45°, in the path of the illuminating and the efferent rays, the latter are in part transmitted by the sheet of glass, and in part reflected at right angles to their original course. Some of the rays which have entered into the formation of the inverted image may be deflected to one side by reflection from a small plane mirror in front of and partially covering the central opening of the illuminating mirror; or some part of the same rays may be similarly deflected by a small reflector, preferably a totally reflecting right prism, placed just behind the illuminating mirror. Demonstrating ophthalmoscopes of this construction have been devised by De Wecker and Roger (Bulletin de l'Académie des Sciences, 1870, and by Sichel *fils* (Annales d'Oculistique, 1872). By slightly separating the two totally reflecting glass thumbs in the binocular ophthalmoscope of Giraud Teulon, and cutting them off square at their ends, an ophthalmoscope for three observers may be produced (Monoyer: Revue médicale de Nancy, 1874); a fourth observer may see the fundus reflected from the illuminating mirror in the direction of the light.

† Coccius was probably the first to construct a binocular ophthalmoscope: a small, perforated plane mirror, set, at an angle of 45°, behind the hole in the illuminating mirror, deflected a part of the efferent rays in a direction at right angles to the line of sight, and a second plane mirror, parallel to and about six centimetres distant from the other, reflected these rays into the second eye of the observer. The two retinal pictures were necessarily of unequal size, but notwithstanding this serious defect, the instrument is said to have given a somewhat better view than when but one eye was used (Sachen und Landolt, Graefe-Saemisch, Handbuch der gesammten Augenheilkunde, III. B., S. 166). The first binocular ophthalmoscope of good construction is that of Giraud Teulon, in which the rays which have traversed the right half of the hole in the mirror are deflected to the right, and the other half to the left, and both are again reflected opposite the two eyes of the observer. All this is very simply accomplished by total reflection at the two obliquely cut ends of two rhomboidal prisms of glass enclosed within a small metallic box behind the mirror (Annales d'Oculistique, xlv., 1861). By a slight change in the construction of this instrument, by Laurence and Heisch, it is made of a little greater weight, although more handsome and more costly. A further modification by Coccius consists in the application of the principle of the common opera-glass, by which the image is seen considerably magnified (Report of the Fourth International Ophthalmological Congress, London, 1872). The latest change in this ophthalmoscope is by its inventor, who has notched the proximal ends of the two thumb-plates so as to make a small central opening, behind which he has placed a very small electric lamp (Giraud Teulon: Annales d'Oculistique, xcvi., December, 1886).

‡ Th. Ruete: Der Augenspiegel und das Optometer. Göttingen, 1852. The Eskens Donders ophthalmoscope (1856) is a fixed ophthalmoscope mounted on a standard, and designed for the measurement of the details of the fundus as seen in the erect image. Ulrich (Henle und Pfeuffer's Zeitschrift für rationelle Medicin, 1853) combined the mirror and objective lens in a short metal tube, to the side of which the candle and was attached. Hasner (Prager Vierteljahrsschrift, 1855) made the tube longer and used a separate lamp; he also mounted both the mirror and the objectives on trunnions. E. Liebreich (Archiv für Ophthalmologie, 1859) constructed his larger ophthalmoscope by mounting an instrument essentially like Hasner's upon a standard and fixing the head of the patient by means of a special rest. With this ophthalmoscope he made the accurate colored representations of the fundus figured in his Atlas der Ophthalmoscopie (Berlin, 1863). Burke (Ophthalmoscopic reflector, Hayle, 1871) constructed a fixed ophthalmoscope in which a second concave mirror, of 19 centimetres (about 8 inches) focus, takes the place of the usual objective in examinations by the indirect method. Carter (Report of the Fourth International Ophthalmological Congress, London, 1872) mounted the several parts of the ordinary hand ophthalmoscope, and on an enlarged scale, upon separate stands resting on a table four feet long; the concave mirror, 4 inches in diameter, is of 15 inches focal length, and the objectives, of 8 inches focus, has a diameter of 1 inches. The patient's head is supported by a chin-rest fixed to the end of the table opposite to the stand supporting the mirror. In all grades of myopia exceeding 5 dioptries (5 D) the inverted image of the fundus is formed between the objectives and the observed eye, in which case the lens takes no part in the formation of the image, but acts only as a magnifier of the image formed by the concave lens; in high grades of hypermetropia, on the other hand, the inverted image is formed at a distance far beyond the principal focus of the objectives, and the field of vision is very small.

* The camera lucida was used with the Eskens Donders ophthalmoscope and with the large ophthalmoscope of Liebreich. Noyes (Transactions of the American Ophthalmological Society, 1873) has also applied it to the large fixed ophthalmoscope of Carter.

‡ Helmholtz (Beschreibung eines Augenspiegels, Berlin, 1851) described a simple method by which an observer may, by looking in a mirror, see the illuminated pupil of one of his own eyes with the other eye. Coccius (Ueber Gesichts-, Farbensinn und die Anordnung des Augenspiegels, Leipzig, 1859) devised an arrangement of light and mirror by which an eye may receive a defined picture of its own optic disk. Hegmann (Die Autoskopie des Auges, Leipzig, 1863) combined a perforated plane mirror, a reflecting prism, and three convex lenses in such a manner that with one eye a view is obtained of the fundus of the other eye in a twice-inverted (*i.e.*, erect) picture. Variations of this apparatus have been devised by Giraud Teulon (Annales d'Oculistique, xlix., 1863) and by Coccius.

forated concave mirror and two vertical standards for holding lenses, all mounted in line, on a horizontal bar (see Fig. 2586). With a convex lens of 1.5 Paris inch (4 centimetres) focus, mounted on the first standard at a distance of one Paris inch in front of the cornea of the observed eye, the inverted image is formed about four centimetres in front of the lens, and is seen, about two and a half times magnified, by the observer looking through the hole in the concave mirror. A second convex lens, of 4.5 or of 3 Paris inches (12 or 8 centimetres) focus, mounted on the second standard at some distance beyond the position of the inverted image, affords the means of viewing this image under an increased amplification. A concave lens, mounted on one of the standards, is used in the examination by the direct method; by moving the standard to and fro along the horizontal bar, two or three concave glasses of different focal lengths are made to serve in rendering the details of the fundus visible in all grades of myopia.[4] Ruete's fixed ophthalmoscope becomes an ordinary hand-ophthalmoscope when the mirror and the convex lens are dismounted, and are held by the two hands of the observer.

Coccius (1853) attached a convex lens to a plane mirror in such a position that the illuminating rays pass through the lens before impinging upon the mirror (see Fig. 2587). The conjoined effect of the convex lens and plane mirror is essentially that of a concave mirror.[5]

Zehender (1854) substituted a convex mirror of 6 Paris inches (16 centimetres) radius of curvature, for the plane mirror in the instrument of Coccius, thus making it possible to obtain from a single convex mirror the effect also of a plane, or of a concave, mirror (see Fig. 2588).[6]

A convex mirror offers a slight theoretical advantage over a plane mirror, as does the latter over a concave mirror, in examinations by the direct method, and the instruments of Coccius and of Zehender have been especial favorites with some excellent observers. They are, however, somewhat more difficult to manage than the concave mirror, and are, at present, but little used. In practice, the perforated concave mirror is found to answer very perfectly for almost all examinations, whether by the indirect or the direct method; for a few cases the polarizing plane mirror of Helmholtz maintains its superiority over all rival inventions.

The ophthalmoscope of Helmholtz, with the two Rekoss disks, includes all that is required for the convenient measurement of the refraction by the direct method, provided only that the disks be made large enough to contain a few more glasses, and that the selection of the glasses be made with special reference to this use. This seemingly obvious improvement was, however, long deferred. Meanwhile, a few exceptionally careful observers had ophthalmoscopes made with a large clip, to receive any one of the series of glasses in the oculist's trial-case (Donders),[7] or with two such clips, intended to hold a spherical and a cylindrical glass (Noyes),[8] or contented themselves with a smaller series of glasses, fitted to a cell or small clip at the back of the mirror (Jaeger).[9]

Loring (1869) was the first to fit the ophthalmoscope with disks containing a series of glasses sufficient for the accurate measurement of the refraction,[10] and it is to this improvement that we must largely ascribe the general recognition of the importance of objective optometry as now practised. Wadsworth (1876) substituted a small mirror, of 15 millimetres diameter, for the larger concave mirror in ordinary use, setting it at a fixed angle of 20° to the plane of the lens-bearing disk, and mounting it in such a manner as to admit of its being turned in any required direction.[11] Following out this suggestion, Loring devised two modifications of the mirror, one in which a small segment is cut off from one side of the mirror, which is hung by a hinge at this border to a revolving setting, the other, the so-called tilting mirror, in which a segment is cut off from each side, and the mirror is swung on two pivots at the two extremities of its long (vertical) diameter.[12] The ophthalmoscope of Loring, as thus perfected, is the type of a thoroughly good instrument for all practical uses; as made by Mr. H. W. Hunter, of New York, it is a model of elegance and fine workmanship.

The essential points in the construction of a good ophthalmoscope are few and simple. The best material for the concave mirror is silvered glass, which should be very thin, in order that the sides of the central perforation may encroach as little as possible upon the effective area of the opening when the mirror is set obliquely to the line of sight; any excess of thickness above .3 millimetres ($\frac{1}{75}$ inch) is both unnecessary and injurious. The central hole should be about 3.5 millimetres (.14 inch) in diameter (Knapp),* and its unpolished margin should be covered with a dull, black pigment to prevent the formation of a disturbing reflex at this point; the alternative expedient of removing the silvering from a small central area of the mirror is not to be commended. A mirror made of polished metal is more difficult to keep in order,

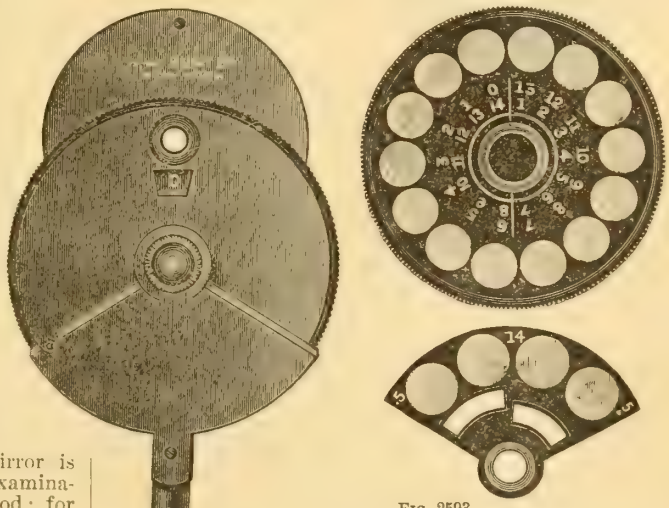

Fig. 2593.

and, unless in very perfect condition, reflects much less light than a mirror of silvered glass. The focal length of the mirror should be about 22.5 centimetres (9 inches); this is a convenient focal length for examinations by the indirect method, and in the direct method the effect is not very different from that of a plane mirror (see Fig. 2553). The mirror should be so mounted as to admit of its being inclined as much as 20°, or, perhaps, 25°, to the plane of the correcting glass, and it is very desirable that it be so arranged that it can be also turned in its cell. For the latter reason, and also because the mirror, when lying flat in its cell, is in closer proximity to the correcting glass, the writer prefers the hinged mirror of Loring to the favorite tilting mirror now in general use.

The correcting glasses should be so mounted as to admit of their automatic centration, and of the easiest possible change from one glass to another, without interrupting the observation by removing the instrument from its position. The series of lenses should be sufficiently large to include the entire range of hypermetropia and of myopia, with intervals as small as can be taken note of by the observer; a common interval of 1 dioptric ($\frac{1}{10}$) will suffice for most practitioners, others may be able to utilize an interval as small as .5 dioptric ($\frac{1}{20}$). A combination of a larger and a smaller Rekoss disk, or of a full disk with about a quadrant of another disk, is sufficient

* H. Knapp (Archives of Ophthalmology and Otology, iv., i., p. 41, 1874) made comparative trials of a number of mirrors with holes varying from one to five millimetres; "the best illumination was obtained by an opening in the mirror of 3.5 or 3.75 millimetres in diameter."

to meet these requirements, the glasses in the principal disk should be of somewhat greater diameter than the hole in the mirror (about 5 millimetres, = .2 inch); those in the second disk should be a little larger (about 7 millimetres = .28 inch in diameter). The two disks should be as thin as the curvature of the glasses will permit, and they should be mounted in the closest possible proximity to each other and to the back of the mirror.

The handle of the ophthalmoscope should be not less than 14 or 15 centimetres (5.5 or 6 inches) long, measuring from the centre of the mirror, and it should be large enough (at least 1 centimetre = .4 inch, in thickness) to admit of its being firmly and easily held in the hand. As, with this length of handle, it is not quite easy to reach the edge of the principal disk with the finger, a cog-and-rack mechanism (Crétès), a cog-wheel (Loring), or a train of cog-wheels (Noyes) has sometimes been added; a very full series, of no less than seventy-four glasses, has also been mounted in a long endless chain in the place of the usual revolving disk (Couper).[13]

Fig. 2594.

If the observer is simply hypermetropic or myopic, he may apply his personal correction to the correcting glass found by observation (see p. 305); if, however, he is astigmatic, it is always better, and sometimes absolutely necessary, to add to the ophthalmoscope such a glass or pair of glasses as may be required to correct his vision for infinite distance. The glass or glasses for this personal correction should be a little larger than the glasses in the second disk (about 9 millimetres = .36 inch, in diameter) and should be mounted immediately behind it; in astigmatism, of even as low a grade as 1 dioptric ($\frac{1}{40}$), its correction adds, materially, both to the sharp definition of the picture and to the observer's quickness of perception.

Fig. 2589 shows the back of an ophthalmoscope made for the writer, in 1876, by Hunter.[14] It is, in fact, one of Loring's smaller ophthalmoscopes, with the addition of a second small disk—a construction adopted, a little later, by Badal, in France. Substituting +13 and −13 for +14 and −14, the order in which the glasses are brought into use becomes precisely the same as in the ophthalmoscope of Badal and in the later ophthalmoscopes of Loring; with +.5 and −.5 in the place of +7 and −7, as figured, an interpolation of .5 dioptric may be made between the limits +6.5 and −6.5. A third disk, with two glasses, serving also as a cover to the smaller disk (Fig. 2590), or a setting of the form shown in Fig. 2591, affords the means of applying such correction as an ametropic observer may find advantageous. The opthalmoscope of Loring, with tilting mirror, in the form preferred by its author, is shown in Figs. 2592 and 2593.[15] The small, inclined mirror of Wadsworth, and the adaptation of it in the hinged mirror of Loring, are shown in Figs. 2594 and 2595.

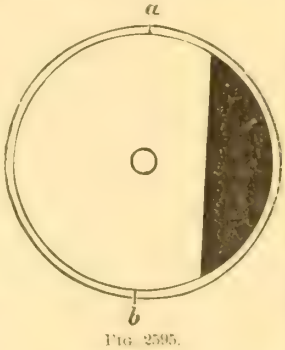

Fig. 2595.

John Green.

In Plate XX. are shown the normal ophthalmoscopic appearances.

[1] Couper: Report of the Fourth International Ophthalmological Congress, London, 1872.

[2] Cuignet: Recueil d'Ophthalmologie, 1873, 1874, 1877, 1880; Mengin: Ibid., 1878; Parent: Ibid., February and July, 1880, 1882; Dianoscope ou Détermination de l'Astigmatisme, Paris, 1881; Lutaud Fortes, Ophthalmic Hospital Reports, 1880; Couney: Ibid., 1882; Motais: Refractions of the Eye, London, 1881; Landolt: Archives Médicales Belges, 1882; Oliver: Lancet, 1882; Jaeger: Ophthalmic Review, 1882; British Medical Journal, 1882; Story: Ophthalmic Review, 1883; Lamolet: Traité Complet d'Ophthalmoscopie, Paris, 1883; Priestley Smith: Ophthalmic Review, 1884; L. Jackson: American Journal of the Medical Sciences, 1885.

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[6] W. Zehender: Archiv für Ophthalmologie, I., 1., 1854.

[7] F. C. Donders: On the Anomalies of Accommodation and Refraction of the Eye. The New Sydenham Society, p. 106. London, 1864.

[8] H. D. Noyes: Transactions of the American Ophthalmological Society, 1869.

[9] Ed. Jaeger: Oesterreichische Zeitschrift für practische Heilkunde, 7. März, 1856.

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[13] Couper: See description of Couper's new Ophthalmoscope, with illustration, in Juler's Handbook of Ophthalmic Science and Practice. London, 1884.

[14] J. Green: Transactions of the American Ophthalmological Society, 1878, p. 476.

[15] E. G. Loring: Transactions of the American Ophthalmological Society, 1878, p. 489.

OPHTHALMOSCOPE, IN GENERAL MEDICINE.

"In the whole history of medicine there is no more beautiful episode than the invention of the ophthalmoscope, and physiology has few greater triumphs. With it it is like walking into nature's laboratory and 'seeing the Infinite in action,' since by its means we are enabled to look upon the only nerve in the whole body which can ever lie open to our inspection under physiological conditions, and to follow in a transparent membrane an isolated circulation from its entrance into the eye through the arteries to its exit in the veins."[1]

By its means we are able to study, daily, morbid changes in every form and variety, from the slightest congestion to the most marked inflammation, and may often, through its agency, obtain the first warning of disease in some distant organ, as the heart, the kidneys, the spleen, the brain, or the spine.

Thus has the invention of Helmholtz, in 1851, given to us a most powerful aid in diagnosis, and placed the ophthalmoscope as one of the foremost instruments of precision in physical diagnosis.

At the same time it is but just to remember that it is not a cerebroscope in the sense that so many writers on neurology would lead us to believe. (For a description of the healthy fundus of the eye, see the preceding article.)

The ophthalmoscope may be of great value to the physician in his daily practice, for by its means many obscure symptoms may be traced which would otherwise remain unknown. It is well known that often the interior of the eye is diseased before any failure of vision manifests itself, and if in this early period, when the patient is under the care of the general physician, with indefinite symptoms, the ophthalmoscope be used, it may reveal albuminuric retinitis, or perhaps the beginning inflammation of the optic nerve due to tumor of the brain. Thus in a large number of diseases intra-ocular changes occur, and may be observed by the ophthalmoscope without difficulty.

The chief changes in the fundus, or bottom of the eye, of interest to the physician, are those seen in the retinal vessels and the optic-nerve entrance, as congestion, neuritis, or atrophy, and those taking place in the retinal tissue. We shall mention some of the more common and usual forms of eye lesion only.

Disease of the Brain.—Tumors. Optic neuritis occurs in about three-fourths of all tumors of the brain, usually occurring on both sides alike and of equal intensity.

The vision is very frequently unimpaired at first, and may be so throughout. In such cases it is that the ophthalmoscope is of great value in the diagnosis.

The following case, seen by the writer at Charity Hospital, illustrates this point: A male, aged thirty, had, for

OPHTHALMOSCOPIC VIEW OF THE NORMAL FUNDUS OCULI.

(Copied after Jaeger.)

H. BENCKE.

six months previous to observation, severe pain, constantly increasing in severity, in the frontal region. The initial lesion of syphilis occurred two years before; the patient was of florid complexion and stout; his gait was unsteady, and his speech was slow; there was no paralysis. Vision was normal in each eye, but ophthalmoscopic examination in the right eye showed media clear, with well-marked papillitis, and great swelling; the retinal vessels were tortuous and turgid, and a few points of extravasation of blood along their course were visible; neuro-retinitis, with "choked disk" well marked. Elevation of papilla one-tenth.

In the left eye a similar condition of the fundus existed, with the arteries in several places covered by exuded material. After treatment for two months the appearance of the optic nerve changed to that of atrophy, the œdema of the nerve and retina giving way. The patient died, and at the autopsy the diagnosis made by the ophthalmoscopic picture was verified by the finding of a syphilitic tumor of the right corpus striatum.

I also well remember another case, showing the value of the ophthalmoscope in the diagnosis of tumor of the brain before loss of vision was manifest. It was in the person of a boy who complained of severe headache, and only one other symptom, viz., blepharospasm. Ophthalmoscopic examination, however, revealed marked signs of *Staüungspapille*, that is, a swollen nerve, looking angry and as if soaked in glycerine, the outline being dim and indistinct; the blood-vessels were tortuous, and the veins were greatly swollen. The picture of choked disk due to brain tumor, once seen, will never be forgotten. In this case the vision was absolutely normal, as the retina in the region of the macula had not yet been invaded; the patient died, and at the autopsy a cystic tumor was found at the base of the brain, impinging on the left optic thalamus.

The size of the brain tumor and the intensity of the optic neuritis seem to have no relation, as frequently at post-mortem examinations a very small tumor may be found in cases in which the intra-ocular symptoms were most marked, and *vice versa*. The rapidity of the growth of the tumor has probably more to do with this than the size; for when it grows slowly the brain accommodates itself to the foreign body.

Often the tumor and the neuritis correspond in their course, each being acute or chronic; the more usual form is the acute, and if the patient survive long enough the optic nerve undergoes atrophy, more or less complete, according to the extent of the inflammatory process. Hence the great necessity of an early diagnosis before much damage is done the optic nerve by the inflammatory exudation.

Abscess. Optic neuritis occurs in a considerable number of these cases, and the following instance is an example where the ophthalmoscope was confirmatory of the diagnosis of abscess of the brain:

Male, aged fifty, for three years had had a chronic suppurative inflammation of the middle ear, which culminated in mastoiditis, with marked cerebral symptoms, such as severe pain in the head, slow pulse, facial paralysis, divergent strabismus, contracted pupil, and semicoma. Ophthalmoscopic examination made at this time showed venous engorgement and optic neuritis; the presence of this optic neuritis led to the diagnosis of abscess of the brain. At the autopsy an abscess of the right cerebellum, the size of a black walnut, was found. The mastoid cells were free of pus, the tympanic cavity containing only a few drops.

Cerebral hæmorrhage gives very rarely any ophthalmoscopic picture; but, on the contrary, cases of *retinal hæmorrhage* give warning to us of the probable future occurrence of hæmorrhages into the brain.

Hemiopia is, however, a frequent occurrence.

Hyperæmia of the brain does not, as a rule, affect the retinal circulation, this being regulated apparently by the intra-ocular tension. This fact is so well known by the ophthalmologist that when he hears of cerebral hyperæmia being diagnosed simply by the ophthalmoscopic appearance of the optic nerve he is incredulous, for it is only after marked and prolonged congestion of the brain that the retinal vessels become changed.

Anæmia of the brain, on the contrary, does show ophthalmoscopic changes in the fundus, especially in cases of leucocythæmia, or in cases of anæmia of the brain, the result of severe hæmorrhages, as from gastric ulcers or the like. In such cases the appearance of optic neuritis is present, and also exudations into the retina, with hæmorrhages, the whole retina having lost its natural color, and being of a yellow-white appearance. These cases are apt to terminate in atrophy of the optic nerve and complete blindness.

Softening of the brain from embolus of a cerebral artery will occasionally cause sudden amaurosis, and the ophthalmoscopic examination will reveal anæmia of the retina, with narrow arteries and veins. In other cases, where the middle cerebral is occluded, increased work is put on the ophthalmic artery, and, as a result, a venous hyperæmia of the retinal vessels and congestion of the optic disk are seen.

Miliary cerebral aneurisms have thus far shown no characteristic eye lesion, although at post-mortem examinations the retinal vessels are found to be affected with minute aneurisms, similar to those found in the brain. It is highly probable that in the future this condition will be noticed during life, and will be found to be confirmatory of the cerebral disease.

Hydrocephalus internus frequently produces optic neuritis, and atrophy of the nerve is the usual sequence. As a rule it affects both sides.

In the cerebral diseases of children the ophthalmoscope in a series of observations showed the following ocular changes: In 63 cases of intracranial disease a morbid condition of the fundus oculi was seen in 47; of these 18 were cases of neuro-retinitis, 13 of neuro-retinitis and papillary engorgement, 4 of congestion of the optic nerve, 4 of optic neuritis, 2 of atrophy (consecutive), and 6 of atrophy.

Meninges.—In tubercular meningitis it is not uncommon to find tubercles of the choroid associated with general miliary tuberculosis; but where only tuberculosis of the pia mater is found, very strangely, they are seldom seen in the choroid. Frequently, however, in this disease, when tubercles are not present in the eye, a marked stasis in the veins will be seen, and occasionally hæmorrhages into the retina, with, in many cases, œdema of the papilla; the parts of the retina lying in the neighborhood are turbid, and, in fact, all the appearances of a neuro-retinitis descendens are to be seen.

Basilar meningitis of a chronic form, when any eye lesion is present, shows the varying degrees of choked disk. To distinguish such cases from those produced by tumor of the brain is very difficult.

Meningitis of the convexity reveals the same symptoms in the eye as those seen in tubercular meningitis, minus the tubercles in the choroid. The neuro-retinitis is apt to be on the same side as the meningitis.

Spinal Cord.—Acute myelitis. In this disease the affections of the optic nerve, such as neuritis, are unknown.

In tabes dorsalis we frequently find, in the first stages, amblyopia, due to a white atrophy of the optic nerve, which is usually progressive and goes on to complete atrophy. At first there will be found a slight discoloration of the disk, which gradually becomes paler, and at last white; at the same time the nutrient vessels of the disk are found to be much diminished or invisible, the field of vision is narrowed, and the sense of color is disturbed, green being lost first, then red, and, finally, yellow and blue. It is one of the frequent complications of tabes, and has been found by Erb, eight times in seventy cases.

Multiple sclerosis supplies not unfrequently cases of atrophy of the optic nerve due to a gray degeneration of its fibres, and going on usually to white atrophy.

Tumors of the medulla oblongata furnish the same intra-ocular picture as other intracranial growths, viz., "choked disk."

In anterior poliomyelitis, acute and chronic, flushing

of the optic papilla has been noticed, but nothing more marked.

In *pernicious anæmia* atrophy of the optic nerve has been found, and of the white variety.

Neuralgia of the fifth cranial nerve has been thought to be the cause of atrophy of the optic nerve in very rare instances.

Exophthalmic Goitre.—Besides the marked protrusion of the eyeball, we frequently, on ophthalmoscopic examination, find a dilatation and tortuosity of the retinal veins, and this fact justifies the assumption of venous hyperæmia of the orbital tissues. The function of the retina is usually unimpaired; the refraction of the eye however, is often changed, owing to the flattening of the eyeball, hyperopia being found. Becker has reported two cases of spontaneous pulsation of the retina.

Chorea.—In this disease all intra-ocular signs are negative. One case of embolism of the central artery of the retina has been reported, but it is highly probable that the ocular disturbance was due to the cardiac disease which existed and not to the chorea.

Epilepsy.—Repeated observations have been made of the fundus oculi during an epileptic seizure, and with most conflicting results. Some state that anæmia, and others that hyperæmia of the fundus is present. The general statement may, however, be made, that during the attack the retina and optic disks are either *normal* in color or *anæmic;* and that immediately after the attack marked hyperæmia of the fundus, due to congestion of the veins, with relative emptiness of the arteries, is to be found.

Diseases of the Kidneys.—It was in the same year that Helmholtz invented the ophthalmoscope that Landouzy made a special study of these affections. Instead of the visual disorders in kidney disease being now looked upon as interesting symptoms in the progress of the disease, they have become an index of *unsuspected* kidney affection and a means of diagnosis. The changes that take place in the retina are, more commonly, retinitis albuminurica, amaurosis uræmica, and detachment of the retina.

Retinitis albuminurica may occur in any form of renal inflammation, and has been seen in the amyloid degeneration, yet it is more commonly associated with the granular or contracted kidney. It occurs during pregnancy and after scarlatina, and may be found in cases of spontaneous origin. The frequency with which it occurs has been variously stated, *e.g.*, Galezowski found it in thirty-three per cent., Lebert in twenty per cent., Lecorche in twenty-one per cent., Earles in twenty-nine per cent., and Ayers in nine and one half per cent. Voelckers, out of thirty cases, found two incident to pregnancy, and the rest were associated with the contracted kidney. It would thus seem that about twenty-three per cent. of patients with renal disease have disorders of vision at some period of the disease. In many cases the renal disease is well established before the eye symptoms present themselves, while, on the other hand, very often the eye lesion is the first indication of general disease. Patients complain of failure of vision, generally in both eyes simultaneously, although it has been seen in one eye, the other remaining normal.

Ophthalmoscopic Appearances.—It is rare that we have the opportunity of seeing the first stage of the disease, but those who have describe the appearances as those of congestion. Subsequently, when the patient presents himself for treatment, we find cloudiness of the papilla and of the adjacent retina, the nerve looks gray and swollen, its margin is indistinct, the retinal veins are large and tortuous, and show points of different color, according as they are deep or are seen more superficially.

The arteries are smaller or normal in size; the retina about the nerve is cloudy and œdematous, with extravasations of blood here and there present, concealing in some instances the vessels. They are sometimes round, and again irregular in shape. We also notice white spots of various sizes, from that of a pin's point to the size of the papilla itself. In the macular region we find, on the temporal side, many fine white dots radiating from it as a centre. These dots look very much as if a brushful of white kalsomine had been thrown upon the retina at this point. Often the previous cloudiness of the retina increases, the exudations grow larger, coalesce, and surround the optic papilla. If the hæmorrhages increase, the specks and dots above the macula will increase and become confluent.

The refraction of the eye in these cases is usually hyperopic, owing to the œdema of the retina. These appearances are usually in both eyes alike, yet they may vary. In some they are much less marked, and we have only the peculiar appearances at the macula, without any swelling of the optic papilla, and with only few and perhaps no hæmorrhages.

These changes may subside again, the white patches becoming smaller, the vessels which they covered becoming again visible, the cloudiness of the retina subsiding, and the outline of the optic nerve appearing. Only in that form following scarlatina, and in that which accompanies the nephritis of pregnancy, do we see occasionally complete absorption; of course, when the optic nerve has had much infiltration in the beginning, more or less damage is done, and atrophy of its fibres will ensue.

Amaurosis uræmica is usually of a transitory character, and the opportunity of an ophthalmoscopic examination is rarely presented. When seen, the retina is usually swollen and œdematous, and in several cases the exudation of serum has been seen to be so great as to produce detachment of the retina. In other cases no peculiar ophthalmoscopic picture is observed.

Diabetes.—We may frequently be led to the diagnosis of this disease by the examination of the eye; not by the discovery of cataract that so commonly is seen in this disease, but from some slight impairment of vision caused by a retinal hæmorrhage due to an extravasation of blood from one of the retinal vessels. A case was seen during the past year, of a woman, forty years of age, who came for the relief of impaired vision, and by the retinal hæmorrhage diabetes was diagnosed. The patient was not aware of the increased flow of urine until her attention was called to diabetes as a cause of her eye trouble. The appearance of hæmorrhages into the retina, with, at the same time, blood in the vitreous, is apt to be produced by diabetes.

Diseases of the Heart.—One of the most common affections of the eye due to heart disease is embolism of the central artery of the retina, due to a plugging of its lumen, and is more usually found in cases of valvular disease. The retinal arteries are so reduced in size as to be scarcely seen, and the retinal veins are dilated; there may also be hæmorrhages scattered throughout the fundus, the retina being more or less opaque in appearance. A bright, cherry spot will often be seen in the macula. Hæmorrhages without exudation may frequently be seen in the retina as a result of arteritis. These rarely, however, produce extreme impairment of vision. Their chief importance is the warning which they give of the condition of the blood-vessels in the brain and throughout the body, and, as previously mentioned, such hæmorrhages occurring in the eye are apt to be forerunners of hæmorrhages into the brain.

Atheromatous degeneration of the retinal vessels reveals itself by opacities in the normally transparent vascular walls, and in some instances by an obliteration of the lumen of the vessel. When the patches of atheroma are large the light streak is diminished or altogether absent.

Hypertrophy of the left ventricle is a cause of retinal hyperæmia, the arteries and veins being both engorged.

Fatty degeneration of the heart, which is often accompanied by a similar condition of the arterial walls, is often the cause of retinal hæmorrhages.

In aortic insufficiency pulsation of the retinal vessels is marked: the contrast between the systole and diastole of these vessels is wonderful. During the systole the arteries swell to a great size, and then suddenly collapse and almost disappear during the diastole. The retinal veins collapse while the arteries are filling, and fill while the arteries are collapsing.

Syphilis.—A form of retinitis has been described as retinitis syphilitica, and it affords certain symptoms

whereby it is possible sometimes to detect the disease by the ophthalmoscope alone.

A gray film seems to cover the retina, and in the macular region numerous punctate spots, irregularly placed, and not so bright as those seen in the retinitis of renal disease; they also rapidly disappear; there is not infrequently a red spot in the macula. Hæmorrhages are rare in this form of inflammation.

Syphilitic retinitis usually occurs with, or shortly after, the secondary symptoms; it may occur rarely in hereditary syphilis.

There is another form, which is found only at the macula, and is called central retinitis.

Disseminated choroiditis is also said to be of syphilitic origin, especially when the masses of exudation are small, circumscribed, separate, and show no tendency to coalesce; and also when the spots have a red hue about them, and are mostly situated at the posterior pole of the eye. The exudations occur both on the inner surface of the choroid and in its stroma. In the later stages of the disease the exudations are absorbed, and the white sclerotic assumes great prominence, the borders of the atrophic spot being fringed by choroidal pigment.

Lead Poisoning.—Optic neuritis has been caused by the absorption of lead into the system, and the optic-nerve atrophy consecutive thereto is usually complete. These cases are fortunately of rare occurrence; we usually see them in the atrophic stage, when the optic nerve is very white. There is little that can be said as to the first stage of inflammation; the changes are probably the result of a low grade of neuritis.

Quinine Poisoning.—In cases in which large doses of quinine have been taken, the ophthalmoscopic picture, a few days afterward, is one of pallor of the optic disk, with all the vessels much narrowed; the vision is normal, but the field of vision is very much contracted.

Chronic alcohol and tobacco intoxication frequently leads to atrophy of the optic nerve, consecutive to a low grade of neuritis set up by the action of the alcohol directly upon the nerve-fibres.

I do not believe that tobacco alone produces amblyopia, but that when alcohol and tobacco are both used to excess we get the deleterious results of their poisonous influence.

Oxaluria has been found complicated with opacities of the vitreous.

Acute General Tuberculosis.—In this disease tubercles are often found, post mortem, in the choroid; yet I have failed after many careful researches and examinations to see any by the ophthalmoscope. The tubercle in the choroid, when seen by the ophthalmoscope, appears like a yellow-white spot, free from any pigmentation. These bodies, when seen during life, give conclusive evidence of the general disease. They are generally found at or near the posterior pole of the eye; they tend to increase rapidly in size and number. Disturbance of vision does not necessarily result from their presence.

Typhus and typhoid fever, and erysipelas, have been known to produce optic neuritis. The following case of optic neuritis, following facial erysipelas, in the writer's practice, is sufficiently rare to warrant its recital. A male, thirty-nine years of age, received a slight cut on the right side of the face near the ear; this soon became affected with acute erysipelas, the disease spreading over the entire face. The eyelids were moderately swollen, but no protrusion of the eye was noticed. The erysipelas was slow to yield, and on opening the eyelids, ten days after the beginning of the attack, the impairment of vision was noticed, although to outward appearances the eye was normal. On the fourteenth day he was seen by the writer, and on ophthalmoscopic examination of the right eye the media were seen to be clear, the optic disk clear in outline, but its substance milky, as was also the retina; the vessels were distorted and tortuous, and there was one small hæmorrhage in the retina, toward the periphery of the fundus; the arteries were smaller than normal; vision was $\frac{1}{60}$. One week later the eyelids were well open, the eye was clear and bright, and the pupil was moderately dilated; vision was the same, the optic nerve was whiter, and the retina less milky; the vessels were smaller, looking as if no blood entered them, and the effused blood was undergoing absorption; one of the vessels looked like a white cord. Two months later the patient was completely blind in the right eye, the other remaining in good condition. The only change noticeable was the complete atrophy of the optic nerve. Drs. Knapp and Coggin have reported similar cases.

Cerebro-spinal meningitis frequently causes a form of irido-choroiditis of a metastatic type which produces atrophy of the optic nerve.

Malarial fevers are known to produce hæmorrhages into the vitreous, especial attention to which has been recently drawn by Dr. C. S. Bull, of New York.

William Oliver Moore.

[1] Loring, E. G.: Text-book on Ophthalmoscopy. New York, 1885.

OPIUM (U. S. Ph.; Br. Ph.; Ph. G.; Codex Med., etc.). The above name, by which the dried milky juice of the poppy capsules is now known in all civilized countries, without regard to language, is developed from the Greek ὀπός, sap or juice, given to it by Dioscorides. From ὀπός to ὄπιον, Latin *opium*, and Opium, the steps are easy. The Asiatic Afyu (Affium, etc.) is a corruption of Opion. Another very early name, *Meconium* (μηκώνιον, μηκώνειον, from μηκών, the poppy), appears to have been used originally for the extract of poppies, and afterward for Opium itself. Among other antiquated synonyms *Succus Thebaicus*, Laudanum, Mecon, *Manus Dei*, *Lachryma Papaveris*, etc., may be mentioned.

Fig. 2596.—The Opium Poppy (var. nigrum; plant much reduced. (Baillon.)

Botanical Source.—*Papaver somniferum* Linn., Order *Papaveraceæ*, is an annual herb with an upright, nearly simple leafy stem, milky juice, and large, showy flowers. The root is yellow, tapering, and branched; the stem cylindrical, simple or slightly branched, solid, smooth, or sparsely bristly, generally glaucous. Leaves numerous, alternate, large, oblong, with wavy or generally serrate and pinnatisect margins, and sessile or amplexicaul bases; smooth and glaucous, or more or less bristly

and spiny. Flowers few, terminal, and in the upper axils, generally solitary, becoming erect from drooping buds, several inches in diameter, regular, perfect. Calyx of two broad, rounded, green sepals, which fall off as the corolla expands; petals, four, large, brilliantly colored, shining, broader than long, of rounded outline, and usually having a spot or eye at the base, texture thin, delicate, surface satiny. The petals are also of brief duration, crumpled in the bud, and falling early. Stamens numerous, with narrow, flat filaments and small linear anthers. The ovary is large, more or less globular, with a depressed top, a constricted neck, and a crown of conspicuous, radiating stigmas; one-celled, with large parietal placentæ. Ovules minute, very numerous, scattered all over these partition-like placentæ. Fruit, a large, dry, rattling capsule of ovoid, globular, pyriform, or compressed shape, according to the variety, with a conspicuously narrowed neck between it and the enlarged receptacle. It opens, when ripe, by small valves beneath the stigmatic rays, except in *Var. album* (see Fig. 2600). There are numerous garden varieties of poppy, involving size (from one to three feet), color (white, pink, red, violet, purple, yellow), shape, and size of capsule, and fulness of flower; of these there are three of some botanical significance and permanence.

Fig. 2597.—Poppy-capsule, about one-half natural size. (Baillon.)

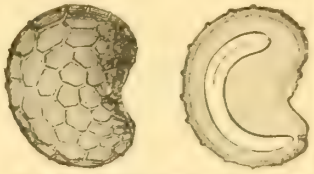


Fig. 2598.—Poppy-seed, considerably enlarged. Section of seed. (Baillon.)

1. *P. somniferum*, *var. setigerum* Boissier, is apparently the wild form. It is sparsely covered with short, soft bristles; the leaves are sharply lobed and toothed, the teeth each ending in a sharp bristle. Plant slender, and capsule comparatively simple, of seven or eight placentæ and stigmatic rays.

2. *Var. glabrum* (*nigrum*) Boissier, smooth or slightly hairy, with medium-sized, generally red or purple, flowers, a subglobular capsule, and usually gray, bluish, or black seeds.

3. *Var. album* Boissier, a larger, stouter plant than the preceding, with light-green, glaucous foliage, very large flowers, six inches in diameter, with usually white petals, and also large, ovoid, *indehiscent* capsules; seeds light-colored.

Of these varieties the first grows spontaneously in the islands of the Levant and in Southeastern Europe, and is not cultivated for use; the second is that cultivated in Asia Minor, Egypt, etc., as a source of opium; and the third is cultivated extensively in Persia, India, etc., for opium, and to a moderate extent in Europe to supply the "poppy-capsules" of the market.

Habitat.—The long-continued cultivation of the poppy has made its native land difficult to discover, but it appears to have extended in all directions from Asia Minor, where its cultivation antedates our knowledge of it. It is now grown extensively in Asia Minor, Egypt, Persia, India, and China, and, for ornament or curiosity, in most other warm, temperate countries.

History.—This has been in part anticipated. As stated above, opium was mentioned by Theophrastus before the Christian era, and by Scribonius Largus, and Dioscorides soon after. Later still, Celsus and Pliny showed themselves acquainted with it and its property of promoting sleep ("Pharmacographia"). From Asia Minor its use extended, with all its beneficent and baneful powers, to the great Asiatic countries, where it has become as indispensable as tobacco and liquor in Europe and America. The passion of the Indians and Chinese for the dreamy intoxication it induces made its consumption in large quantities there an unavoidable consequence, but its spread was hastened by the policy of the British traders in India, who first sent it openly, and then, after it was prohibited by the government, smuggled and forced it into the Chinese markets, and finally succeeded in arousing the home government to prosecute the disgraceful so-called "Opium War" against China, which resulted, about a generation ago, in obtaining free entrance for what had become one of India's most important agricultural products.

Secretion.—The poppy is abundantly supplied with laticiferous vessels, so that it cannot be wounded anywhere without the liquid escaping; in the stem they are in longitudinal lines and bundles just beneath the bark, but in the capsules in an extensive system of reticulated meshes (see Fig. 2601) accompanied by spiral vessels, etc., and enclosing the simple parenchyma in irregular roundish spaces. These vessels, just before the fruit is ripe, are so filled with the latex that it wells out at the slightest puncture.

Production.—All opium is the product of cultivated plants, sown and tended with considerable care, and adjusted in successive crops in order to extend the laborious task of collection as much as possible. A few days after the petals have fallen the collectors go through the fields, take the heads that are ready, one by one, and make a careful circular or spiral cut around each, deep enough to go well into the parenchyma but not through the wall; the white juice immediately exudes and dries around it, and next day is scraped off by the collector with a knife, and wiped upon a poppy-leaf or some receptacle that he carries in his left hand. As the soft opium accumulates he moulds it into a roundish lump, and lays it by to dry

Fig. 2599.—Flower of White Poppy, less than natural size. (Baillon.)

In all countries the principle remains the same, while the details differ. Instead of the simple knife an instrument with a number of points may be used to scarify the capsule, and the collected juice may be moulded in different forms or mixed with other substances, according to the requirements of the trade.

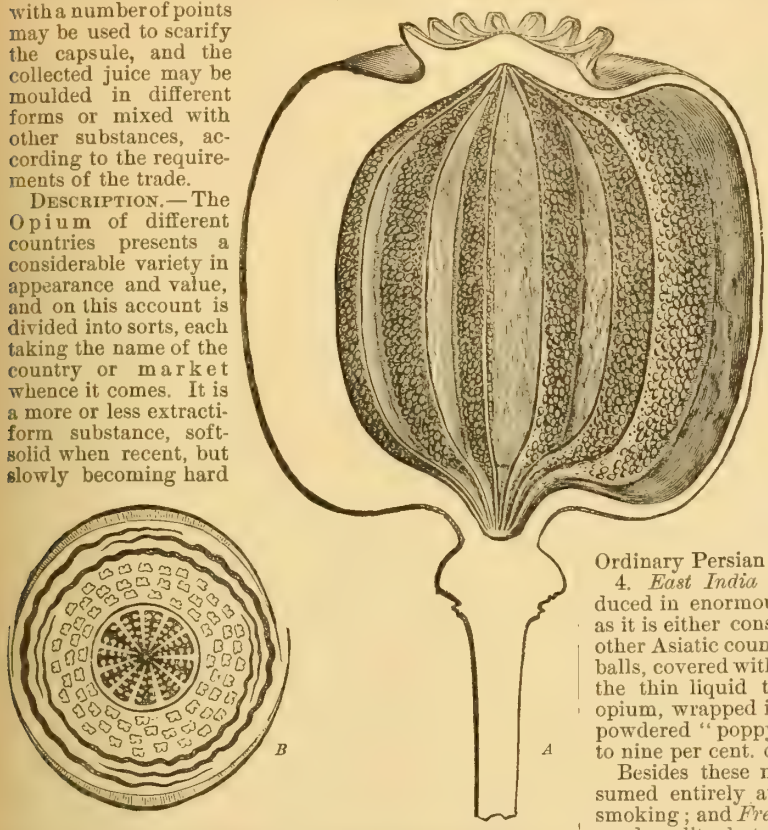


FIG. 2600.—White Poppy-capsule. A, section showing the wing-like placenta. B, plan of the Flower. (Baillon.)

DESCRIPTION.—The Opium of different countries presents a considerable variety in appearance and value, and on this account is divided into sorts, each taking the name of the country or market whence it comes. It is a more or less extractiform substance, soft-solid when recent, but slowly becoming hard and brittle, of tan-brown, umber-brown, or blackish-brown color, darkening by age; in some varieties of homogeneous, in others of granular structure, in all of a disagreeable, sickening odor that has been termed narcotic, and has some resemblance to that of bruised lettuce, and of a bitter, nauseous taste. It occurs in masses of roundish or fantastical shapes, and of varying sizes, from one or two ounces to half a dozen pounds. It often contains fragments of vegetable (poppy) tissue, and generally numerous minute crystals. The following are the principal sorts:

1. *Turkey Opium* (Levant Opium, Smyrna and Constantinople Opiums, etc.). "In irregular or subglobular cakes, with the remains of poppy-leaves and fruits of a species of Rumex adhering to the surface; plastic, or of a harder consistence; chestnut-brown or darker, and somewhat shining; internally showing some tears and fragments of vegetable tissue. It has a sharp, narcotic odor, and a bitter taste. . . . Opium, in its normal, moist condition, should yield not less than nine per cent. of morphine." "Smyrna" and "Constantinople" Opiums are sometimes described as separate varieties of this sort, the latter produced in the northern part of Asia Minor, near the Black Sea, and about Constantinople itself. It is said to lack the granular, tear-like structure of the other, which it otherwise resembles. This is Opium U. S. Ph., etc.

2. *Egyptian Opium*, from Upper Egypt. There is a considerable amount produced, but not much imported into Europe, and practically none in America. It is a rather poor kind, containing from three to six per cent. of morphine, and is made into hard, dark-colored, flattish cakes covered with poppy-leaves.

3. *Persian Opium* is not commonly met with here, but Dr. Squibb described a lot ("Ephemeris," i., 291) which he purchased some years ago, and which was of very good quality. It was in plano-convex lumps, of thirteen ounces each, of a shining, chocolate-brown color, greasy surface, and fine, homogeneous structure. It yielded, moist, ten or eleven per cent. of morphine. Ordinary Persian Opium is usually of inferior quality.

4. *East India Opium.* This variety, although produced in enormous quantities, has little interest for us, as it is either consumed at home or exported to China or other Asiatic countries; never here. It is made into large balls, covered with a sort of glutinous extract made from the thin liquid that drains from the freshly gathered opium, wrapped in poppy-petals, and packed in coarsely powdered "poppy-trash." It contains from four or five to nine per cent. of morphine.

Besides these may be mentioned *Chinese Opium*, consumed entirely at home and cultivated exclusively for smoking; and *French*, *German*, and *American Opiums*, of good quality, but only cultivated in an experimental way.

COMPOSITION.—This naturally most complex substance is probably made still more so by decomposition-processes going on during its long moist condition. Of this, however, there is no direct proof, although the facts that but few of these substances have been found in fresh poppy-tissue, and that some of them are capable of synthesis

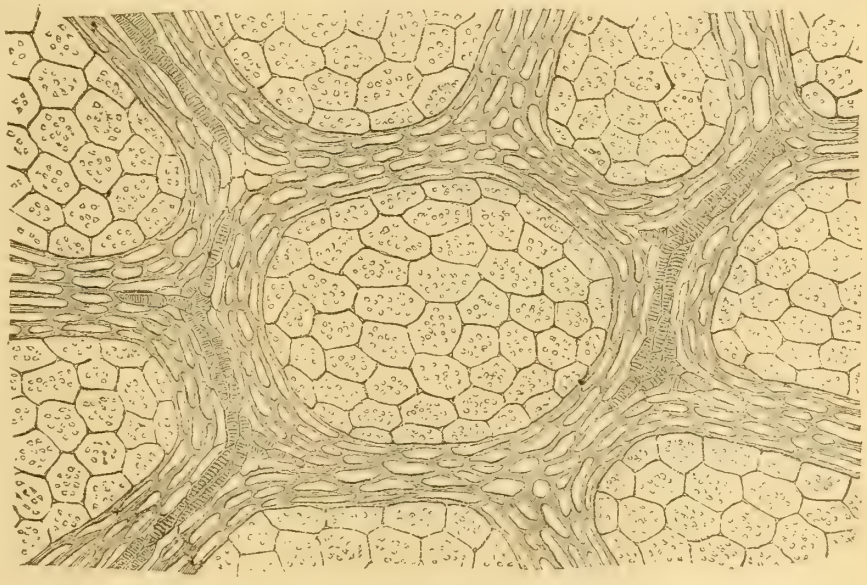


FIG. 2601.—Laticiferous System of Poppy-capsule. (Baillon.) A tangential section just beneath the surface. Magnified.

from others, lend support to this view. The number of its immediate derivatives, according to our present knowledge, exceeds thirty, and is likely to be increased. Of these, seventeen are alkaloids, four or five neutral principles and acids, and the remainder the more ordinary constituents of plant tissue. Only three (alkaloids) of the whole number have any great value, and of these only one is indispensable. The rest are either insignificant or deleterious. The following list is compiled from the "Pharmacographia," from Husemann, Hager, and other standard authorities:

FIG. 2602.—White Poppy. Showing the incisions made in the green capsule for the extraction of opium. (Baillon.)

ALKALOIDS.—1. *Morphine* (*Morphina*, U. S. Ph., from *Morpheus*, the god of sleep). This most important principle, not only of Opium, but of the entire materia medica, and also the first-discovered alkaloid, was announced by Setürner, in 1816. His method of isolation, the basis of most others, was essentially to exhaust the Opium with hot distilled water, evaporate the solution to a syrupy consistence, and precipitate with ammonia. The impure salt was then redissolved and crystallized. Other chemists exhaust the Opium with cold or with acidulated water and decompose the Morphine salt with carbonates or chlorides of the alkalies, or treat it instead with milk of lime, which holds the Morphine in solution, and then precipitate it as above. In all cases it has to be redissolved, purified, and recrystallized one or more times. The proportion obtained varies considerably, even in good varieties. The highest percentage, twenty-two and eight-tenths, was found by Guibourt, in a sample collected in the South of France; others from the same locality yielded twenty and twenty-one per cent., and still others from ten to fifteen. The best report of the Opium of Asia Minor, twenty-one and forty-six hundredths per cent., is also recorded by Guibourt. But these amounts are exceptional. The usual percentage of good Smyrna Opium (dried) is from ten to fifteen; more than the latter is uncommon, and less than the former is suspicious. The other varieties of Opium are generally much poorer. Egyptian and Persian sorts seldom yield more than half as much as Smyrna, and those of India usually still less. A little American Opium, cultivated many years ago, contained fifteen and three-fourths per cent. Morphine is a permanent, crystalline substance, giving an alkaline reaction in solution, and forming with acids neutral, often crystallizable, salts. It is very insoluble in cold water, but dissolves in five hundred parts if boiling; soluble in one hundred parts of alcohol. Chloroform scarcely dissolves it, and ether not at all. "Nitric acid first reddens Morphine and then turns it yellow. With test-solution of ferric chloride (ten per cent. aqueous) Morphine yields a blue color, which is changed to green by an excess of the reagent, and destroyed by free acids or alcohol, but not by alkalies."

2. *Codeine*, $C_{18}H_{21}NO_2H_2O$ (*Codeina*, U. S. Ph.; from κώδεια, the poppy), is second to Morphine in importance, and is usually isolated in the course of the purification of that alkaloid. The yield is from one-fourth to one half per cent. This is also a permanent, strongly alkaline, colorless, or faintly yellow solid. From ether it crystallizes in fine, anhydrous crystals, but from water in large, alum-like, rhombic prisms, sometimes as large as an egg, generally less than a centimetre across. It is odorless and bitter, slightly efflorescent, soluble in eighty parts of water, six of ether, and much less of alcohol or chloroform. Added to nitric acid Codeine dissolves, making a yellow liquid, not red, as is the case with Morphine. Codeine may be made from Morphine by means of methyl iodide.

3. *Narceine*, $C_{23}H_{29}NO_9$ (νάρκη, torpor), was discovered by Pelletier in 1832, and is isolated to the extent of from one tenth to one half per cent., by a complicated process, from the liquid out of which Morphine is precipitated, in the preparation of that alkaloid. Narceine is a weak base, whose alkaline properties have even been doubted. It is usually found in very white, long, fine, silky or cotton-like needles, of no odor, but a slowly developing, bitter, astringent taste. It requires three hundred and seventy-five parts of cold water (1.285, Hesse) for its solution, but is more soluble in diluted alkalies (ammonia, soda, etc.). It is comparatively insoluble in cold alcohol, and quite so in ether, and is not colored by dilute acids.

The above three are all the Opium alkaloids that have any employment in medicine. The next is abundant and cheap, but has not been found to have any valuable properties; the succeeding ones are scarcely to be considered as of other than chemical and physiological interest.

4. *Narcotine* (ναρκωτικός). Discovered in 1803 by Derosne, but its alkaloidal character not made out until 1817 by Pelletier; it is supposed to exist uncombined in the crude Opium, and is left behind, on account of its insolubility in water, when the other alkaloids are extracted, and can be removed from the residue by diluted hydrochloric acid, precipitated from solution by bicarbonate of soda, and further purified by solution in boiling alcohol and crystallization. It can also be removed from Opium by treatment with ether, which dissolves out the Narcotine and leaves the valuable alkaloids behind. The proportion of this alkaloid in Opium varies very much. Smyrna Opium usually contains but one or two per cent.; Persian and Indian Opiums frequently from four to eight or more. A sample of German Opium yielded Flückiger ten and nine-tenths per cent., the largest amount recorded. Narcotine crystallizes with ease in colorless, brilliant prisms. It is odorless, tasteless, and neutral in reaction; almost insoluble in water, cold or hot; dissolves in one hundred parts of alcohol, one hundred and sixty-six of ether, and three of chloroform.

5. *Thebaine* (Thibouméry, 1835). In white silvery scales or needles of sharp, styptic taste and alkaline reaction. Insoluble in water, rather easily soluble in alcohol. Proportion, from one-sixth to one per cent.

6. *Papaverine* (Merck, 1848). Crystalline. Insoluble in water, nearly so in cold alcohol and ether, more soluble in chloroform. One per cent. (T. & H. Smith).

7. *Pseudomorphine* (Pelletier & Thibouméry, 1835). Finely crystalline. Insoluble in water, alcohol, ether, and chloroform; soluble in alkalies and lime-water. Neutral, tasteless. One or two-hundredths of one per cent.

8. *Gnoscopine* (T. & H. Smith, 1878). Crystalline.

9. *Codamine* (Hesse, 1878). Crystalline.

10. *Laudanine* (Hesse, 1870). In large crystals.

11. *Laudanosine* (Hesse, 1871). Crystallizable.

12. *Meconidine* (Hesse, 1870). Amorphous; not stable.

13. *Lanthopine* (Hesse, 1870). Finely crystalline.

14. *Protopine* (Hesse, 1871). Crystallizable.

15. *Cryptopine* (T. & H. Smith, 1864). Crystallizable.

16. *Hydrocotarnine* (Matthiesen & Wright, 1869). Crystallizable.

17. *Rhoeadine* (Hesse, 1865). Found in the tissues and juices of both *P. Rhoeas* and *P. somniferum*, and in Opium; crystalline, very insoluble.

NEUTRAL PRINCIPLES.—18. *Meconin* (Dublanc, 1826; Couerbe, 1832). Crystalline.

19. *Meconiosin* (T. & H. Smith, 1878).

ACIDS.—20. *Meconic Acid* (Setürner, 1805). This can be rather easily prepared, by precipitating the liquid from which the morphine has been removed by ammonia or otherwise, by barium chloride decomposing the barium meconate, by sulphuric acid and purifying, or by several other methods. Amount, from three to five per cent. Meconic acid crystallizes in fine prisms or shining scales; has a sour taste and sharply acid reaction; is easily solu-

ble in alcohol, less so in ether and cold water, and not at all in chloroform. It is the acid with which Morphine is combined in Opium, and is probably also combined with some of the other alkaloids.

21. *Loctic Acid* is found by the Messrs. Smith in Turkey Opium to the extent of two per cent.; probably a decomposition-product.

Miscellaneous and widely diffused Plant-substances.—*Fat*, from one to three per cent.; *caoutchouc*, from three to eight; *resin*, from two to six; *gums*, from ten to twenty; *water*, from ten to fifteen; *ash*, three, etc.

Action and Use.—A. *Absorption and Elimination.*—The active portions of Opium are readily absorbed from the stomach, slightly less quickly from the rectum, more slowly from the vagina, very little from the skin, and almost not at all from the bladder. From the air-passages, administered in spray or powder, enough is absorbed for local effect, and but little more; from abraded surfaces and granulations absorption is irregular, and may be too little to be of any benefit, or, on the other hand, too much for safety. From subcutaneous injections it is diffused with great regularity and effectiveness. In man, the usual time of absorption of a medicinal dose is as follows: By the stomach, empty or in active condition, the first symptoms appear in fifteen or twenty minutes, the full effect in, say, an hour; by the rectum, one must allow from once and one-half to twice as long, and about one-third larger dose for the same results; by the vagina, at least twice the time and twice the dose for any general effect; by the skin, only local results can be looked for. Hypodermatically, the first effects are generally felt in from three to five minutes, and the full influence in from fifteen to thirty. Of the fate of Opium in the system we know really but little. Its elimination in an unchanged condition (Morphine) appears to be very variable, and in small quantity. Thus most physiologists consider the kidneys to be the main channels of its exit, and have found it in the urine; yet others (Landsberg, etc.) have failed to find it. It is probable that a portion of it only appears in this way, and much more is oxidized, or in some way used up in the body. It has been found in the fæces, and a little finds its way out through the skin. An important channel, from a practical point of view, is through the breasts of nursing women, since children are occasionally affected by the milk, and have even died from poisoning in this way. Ordinarily, elimination of Opium is moderately rapid, but in poisonous amounts its action upon secreting organs may retard its own passage out. Medicinal doses, nearer together than two or three hours, are pretty rapidly cumulative; on the other hand, infrequent doses (from one to three a day) produce pretty rapid tolerance.

B. *General Action upon Animals, etc.*—There is considerable apparent diversity in the effects which this drug has upon different organisms; thus it retards the motions of some sensitive plants, it paralyzes and convulses fishes, produces first loss of co-ordination, and, later, tetanic convulsions in frogs, convulses mice, stupefies the dog, and, finally, has but little effect upon birds. The pupils are dilated in some animals, contracted in others, and unaffected in a still larger number. Thus, while many animals are put to sleep by it, the majority seem to be made uncomfortable and restless, and subject to convulsive explosions—the predominance of one or another set of symptoms appearing to be related to the proportionate cerebral development of the subject. Where this is great, they are more soporific; where it is less, more convulsive; and, among men, the more nervous and unbalanced individuals suffer more from the discomforts attending its action, and experience less of its cerebral calmative action. The ordinary effects upon man are as follows, and occur in nine-tenths or more of those who take it: A short spell of conscious comfort and good feeling, freedom of thought, bodily and mental calm, a warm, pleasant, slightly numb feeling, especially in the finger-tips and toes, absence of hunger, slight dizziness and absent-mindedness, dryish tongue, indifference to slight annoyances and discomforts, diminished pupils, sleepiness, and, if yielded to, sleep. Upon waking, if the dose is an ordinary medical one, more or less uncomfortableness, slight nausea or aversion to food, dry tongue, and the omission of the next regular stool. (For the action of large doses and for the Opium habit, see the two next succeeding articles.) There is probably an undercurrent of each of the other classes of effects in every case, but in a typical one like the above they are so entirely overshadowed by the brain stupor as to be unnoticeable.

C. *Action of the alkaloids.—Morphine.*—As this is the principal, and for human medicine the typical, constituent of Opium, nearly all that is said here of morphine can be predicated for the entire drug, and what has been said above of opium need not be repeated here. It is the most actively poisonous of the alkaloids to man, but less so to some animals than thebaine, which is comparatively harmless in the human system. According to Dr. S. Weir Mitchell, it requires from one-half to one gram to kill a pigeon, while a fourth part as much would be fatal to man. "It is said to be less soporific to animals than narceine, but more so than codeine" (Phillips). The convulsions, etc., recorded above of Opium are also produced by morphine. The circulation is at first stimulated, as shown by increased frequency of pulse, followed by slowing and increased force, but in moderate doses it soon becomes normal; in large ones, on the other hand, it becomes weak and rapid. The respiration is, almost from the first, depressed, and after large doses becomes characteristically slow and insufficient. In fatal cases it is generally the first function to stop, probably from paralysis of the respiratory centres (Wood). Morphine diminishes nearly all secretions; those of the mouth as shown by the dryness of tongue and fauces which follows it; those of the skin as shown by its dryness after a medium dose (large doses cause the sweating of collapse). Digestion is impeded, and constipation is caused by its presence. The quantity of urine is diminished. Regarding the diminution of bile, there is difference of observation. Peristalsis is diminished. The pupils in man are almost invariably contracted, at least until just before death.

Codeine acts very much like morphine, but is weaker, requiring five or six times as large a dose for the same effect; upon animals it is more convulsant. It produces a quieter but less certain sleep than the former, is less likely to be followed by headache, constipation, and other unpleasant symptoms, and has much less influence over pain.

Narceine.—Of this alkaloid but little positive can be said. It is generally regarded as a mild and pleasant hypnotic, but is certainly not very reliable, and so little called for that its uniform purity is doubtful. One or two grains (0.1 Gm.) are sometimes followed by sleep. On the other hand, ten and twenty have been taken with little or no result.

Narcotine appears to have no valuable properties. It is not narcotic or analgesic. It has been used as an antiperiodic.

Papaverine.—Not in use. Slightly, if at all, hypnotic; moderately convulsant to animals.

Thebaine.—The most intense spinal stimulant of the group. Allied to strychnine; not narcotic. Not in use.

D. *Untoward and Unusual Symptoms produced by Opium in Man.*—It is natural to suppose that an agent producing such antagonistic effects as Opium does in the sleep and coma of dogs, the delirium of horses, the restless nervousness of birds, and the convulsions of mice and many other animals, shall not be perfectly uniform in its effects upon man, and such is the case; different races and ages of men, different temperaments, and different conditions of health, and personal idiosyncrasy may bring to the front any one of these symptoms. Thus Malays and negroes are excited by it, children may have convulsions. "Nervous" persons are frequently kept awake, and occasionally made wildly delirious, by it, or suffer from cramps, numbness, excessive vomiting, or even collapse, after ordinary doses. Itching of the skin is not uncommon and may be intolerable. Headache and vom-

iting are frequent. Anæsthesia without loss of consciousness may be present, but is rare. Serious coma may follow small doses in certain diseased conditions, as in anasarca and some cases of albuminuria. Medicinal doses have occasionally been followed by death.

Therapeutic Application.—The principal utility of Opium and Morphine (for the other alkaloids have little value in this respect) is due to its marvellous power over physical pain, from whatever cause, and in whatever part of the body, which it diminishes both locally and centrally—locally, by paralyzing the nerve extremities to a slight degree; centrally, by its more intense effect upon the centres from which the sensation is referred. For this purpose it is more or less indicated in nearly all acute diseases, in many chronic ones, and in accidents. Thus its value in neuralgia, rheumatism, colic, pneumonia, peritonitis, gastrodynia, some forms of dyspepsia, migraine, hepatic and renal colics, pleurisy, cystitis, cancers, and many other disorders, indicate it to be almost a universal panacea, the amount of whose beneficence can be hardly appreciated. In many of these diseases it is, however, more than a simple palliative; for, by reducing at the same time unnecessary motion, it diminishes the cause of pain and the danger of the disease in peritonitis; by relaxing spasm it tends to cure the above named colics, etc. In some cases, also, it appears to have a direct curative power.

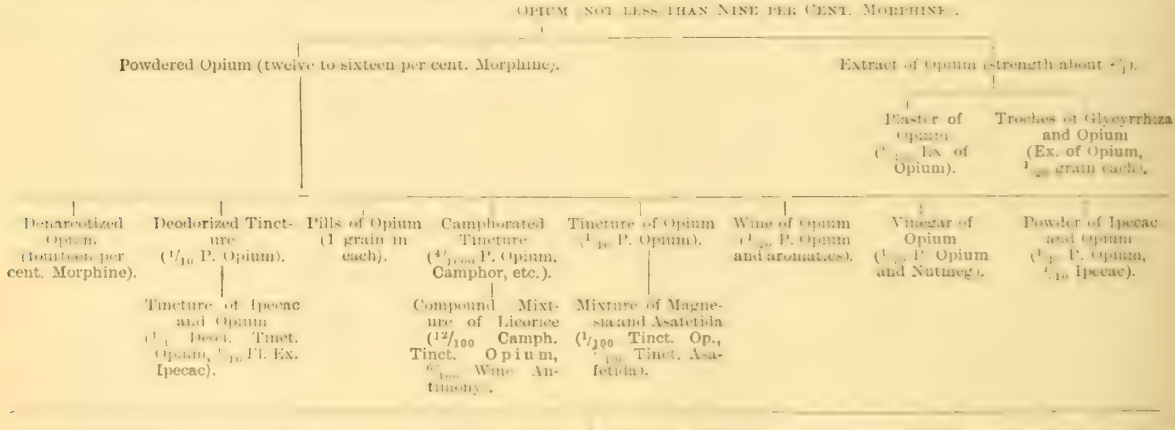
As a soporific, although powerful, it is far less useful, except for temporary occasions; in habitual sleeplessness it is worse than useless; in nervous wakefulness it frequently intensifies the trouble. It is recommended by some alienists in melancholia, and kept up week after week; but its real usefulness is open to question. In delirium tremens it has long been a favorite, and is frequently of great service; but here it is not free from danger, and has yielded place largely to chloral and bromide. In the insomnia of the acute fevers it is unequalled; in the distressing "coma vigil" of typhoid its effect is sometimes marvellous; in the adynamic muttering delirium of this and kindred diseases it seems to cure as well as relieve. Its power of relieving spasm indicates its use in asthma, colic, obstruction of the bowels (some cases), biliary and renal calculi, spasmodic stricture, rigid os, cramps in muscles, fractures, etc.

Its effect upon secretions, both normal and abnormal, makes it of the greatest usefulness in diarrhœas (where it also reduces peristalsis), salivation, dysentery (quiets pain also), sweating of debility, coryza (used early), bronchitis, etc., and in diabetes, where not only the quantity of urine is diminished but the amount of sugar. Codeine is usually recommended for this disease, but its advantage over morphine is probably not great. Suppression of urine is often simulated by Opium, when retention caused by sluggishness of the bladder only is present. On the other hand, Opium will cause a free return of the suppressed perspiration of a cold, and frequently abort the course it would take, especially if other sudorific means be tried with it.

Besides the above classes, it is in frequent use in numerous diseases when the benefit derived is from a combination of two or more of the effects classified above, or may not fall easily into any of them. Thus it is claimed by some to abort boils if applied as a thick extract over them, but frequently fails. It is supposed to hasten the cure of ulcers (taken internally); it relieves the distress of valvular disease of the heart; it is of some, but not much, benefit in tetanus; it has been recommended in chorea; it quiets uræmic convulsions (in full doses hypodermatically); it is given in whooping-cough. In sea-sickness, in vomiting of pregnancy, in gastric ulcers it is frequently of use.

Administration.—Crude, undried Opium is occasionally given in pill form when slow solution is desired, as in cases of relaxed diarrhœa, diarrhœa of phthisis, and chronic dysentery. Old and hard pills are sometimes written for (and many apothecaries keep them on hand for the purpose), in the hope that they will pass the stomach undissolved and exert a local continuous influence upon the intestine. This result is, however, not exactly within control, and may be better attained by coating pills with keratin. The dose of crude Opium is from five to fifteen centigrammes (gr. j. ad jiss.).

The following table exhibits the preparations of our Pharmacopœia and the proportion of Opium in each:


Opium not less than Nine per Cent. Morphine.
Powdered Opium (twelve to sixteen per cent. Morphine).
Extract of Opium (strength about ¼).
Plaster of Opium (⅒ Ex. of Opium).
Troches of Glycyrrhiza and Opium (Ex. of Opium, ¹/₂₀ grain each).
Denarcotized Opium (fourteen per cent. Morphine).
Deodorized Tincture (¹/₁₀ P. Opium).
Pills of Opium (1 grain in each).
Camphorated Tincture (⁴/₁₀₀ P. Opium, Camphor, etc.).
Tincture of Opium (¹/₁₀ P. Opium).
Wine of Opium (¹/₂₀ P. Opium and aromatics).
Vinegar of Opium (¹/₂₀ P. Opium and Nutmeg).
Powder of Ipecac and Opium (¹/₉ P. Opium, ¹/₁₀ Ipecac).
Tincture of Ipecac and Opium (¹/₁ Deod. Tinct. Opium, ¹/₁₀ Fl. Ex. Ipecac).
Compound Mixture of Licorice (¹²/₁₀₀ Camph. Tinct. Opium, ⁶/₁₀₀ Wine Antimony).
Mixture of Magnesia and Asafetida (¹/₁₀₀ Tinct. Op., ¹/₁₀ Tinct. Asafetida).

The alkaloids of Opium are not technically "preparations," as they are treated as distinct chemicals by the Pharmacopœia. The officinal ones are Morphine (*Morphina*, U. S. Ph.), Acetate of Morphine (*Morphinæ Acetas*, U. S. Ph.), Hydrochlorate of Morphine (*Morphinæ Hydrochloras*, U. S. Ph.), Sulphate of Morphine (*Morphinæ Sulphas*, U. S. Ph.), and Codeine (*Codeina*, U. S. Ph.).

Narceine is not officinal. Besides these, Sulphate of Codeine and other salts of Morphine, including the Meconate, are in the market.

The selection of one or another of these preparations is to some extent a matter of personal habit, as there are several duplicates among them. Opium itself and its Galenical preparations are considered to be more stimulating to the nervous system and more quieting to the bowels—that is, constipating—than the alkaloids, and they are preferred in flooding, collapse, and bowel troubles. They are, however, at least unless the denarcotized preparations are used, more apt to produce nausea, vomiting, headache, and other nervous disturbances, than the alkaloids.

Of the solid preparations of Opium the *Denarcotized Opium* (*Opium Denarcotisatum*, U. S. Ph.) is the most desirable for internal administration. It is prepared by exhausting powdered Opium with Ether (in which Morphine is insoluble), to remove the narcotine, etc., and then adjusting it with Sugar of Milk to a standard of fourteen per cent. of Morphine. Dose, from five to ten centigrammes (gr. ss. ad jss.).

Dover's Powder (*Pulvis Ipecacuanhæ et Opii*, U. S. Ph.) has the following formula:

Powdered Opium	10 parts.
Ipecac	10 "
Sugar of Milk	80 "

Mix thoroughly and rub fine. Dose, from one-half to one gramme (grs. v. ad xv.).

The Ipecac is intended to add relaxing, expectorant, slightly nauseating, and sudorific effects to those of the Opium. This preparation is appropriate for febrile diseases, especially at the beginning, but is frequently carelessly given when only an opiate is intended.

The *Pills* (*Pilulæ Opii*, U. S. Ph.) are made up with enough soap to give them a proper texture. One is an ordinary dose.

The *Troches* (*Trochisci Glycyrrhizæ et Opii*, U. S. Ph.) are mixed with Licorice, Acacia, Sugar, and Oil of Anise. They are useful in pharyngitis, etc. Five or six may be dissolved in the mouth during the day.

The *Plaster* (*Emplastrum Opii*, U. S. Ph.) has little or no value.

Of the liquid preparations the *Tincture* (*Tinctura Opii*, U. S. Ph., Laudanum) is by far the most extensively used, and the cheapest and most serviceable for liniments, washes, and other external uses. The Mixture of Magnesia and Asafetida (*Mistura Magnesiæ et Asafœtidæ*, U. S. Ph., Dewee's Carminative) contains Laudanum, one per cent.; Tincture of Asafetida, seven; and Carbonate of Magnesia, five; in sugar and water.

The *Deodorized Tincture* (*Tinctura Opii Deodorata*, U. S. Ph., McMunn's Elixir, essentially) corresponds to denarcotized Opium and is the best for internal use; it is prepared by exhausting the Opium with water, concentrating the liquid, shaking it with Ether, which removes some of the odorous and disagreeable substances, and adding Alcohol for final adjustment. The *Tincture of Ipecac and Opium* (*Tinctura Ipecacuanhæ et Opii*, U. S. Ph., "Liquid Dover") is made from the above.

Vinegar of Opium (*Acetum Opii*, U. S. Ph., the old "Black Drop" made weaker). Here the Opium is exhausted with diluted Acetic Acid, and flavored with Nutmeg and Sugar—an elegant preparation, but superfluous.

Wine of Opium (*Vinum Opii*, U. S. Ph., Sydenham's Laudanum in the main), made with Sherry Wine and flavored with Cinnamon and Cloves, also superfluous.

The above three tinctures, wine, and vinegar have all the same strength and dose by measure, but not by drops, as those of the vinegar are about a minim (.06), while those of the tinctures and wine are not much more than half as large.

The *Camphorated Tincture* (*Tinctura Opii Camphorata*, U. S. Ph., Paregoric) is an elegant but weak elixir; its composition is:

Powdered Opium	4 parts.
Benzoic Acid	4 "
Camphor	4 "
Oil of Anise	4 "
Glycerine	40 "
Alcohol, enough to make	1,000 "

Paregoric is in universal use as a domestic anodyne, especially in complaints of children where pain, wakefulness, cough, diarrhœa, and collapse are symptoms. It is also given to adults for cough, diarrhœa, and slight pain. Adult dose, fifteen or twenty cubic centimetres (℥ ss.); in cough-mixtures, one-fifth or -fourth as much. The *Brown Mixture* (*Mistura Glycyrrhizæ Composita*, U. S. Ph.) contains Paregoric, but is essentially a preparation of Antimony.

Of the administration of Morphine salts little need be said; they are all therapeutically alike, and all sufficiently soluble in water and Alcohol (Acetate, 12 of water, 68 of alcohol; Hydrochlorate, 24 of water, 63 of Alcohol; Sulphate, 24 of water, 702 of Alcohol) to be easily dispensed in solution; they are fairly permanent in the air, although the Acetate effloresces a little, and can be made to keep well in solution by adding one-sixth of one per cent. of Carbolic Acid, half as much Thymol, or a little Salicylic Acid to the distilled water used. Dose of either, about one centigramme (.01 = gr. ⅙). The Sulphate is almost always used in this country, the Hydrochlorate in England.

The *Compound Powder of Morphine* (*Pulvis Morphinæ Compositus*, U. S. Ph.), Tully's Powder, contains:

Sulphate of Morphine	1 part.
Camphor	20 parts.
Glycyrrhiza	20 "
Precipitated Carbonate of Calcium	20 "
Alcohol, q. s. to rub the Camphor to powder.	

Dose, from one-half to one gramme (grs. viij. ad xv.).

It is considerably used as a diaphoretic soporific in a similar way to Dover's Powder, of which it is a duplicate.

Troches of Morphine and Ipecac (*Trochisci Morphinæ et Ipecacuanhæ*, U. S. Ph.) each contain a fortieth of a grain of *Morphine* and one-twelfth of a grain of Ipecac. For pharyngitis, etc.

Codeine and *Narceine* are best given in pills. Dose, from five to ten centigrammes (gr. ss. ad ij.) Salts of Codeine, which are more soluble, are to be had.

It should be remembered that children, especially infants, are especially susceptible to Opium, and that the usual $\frac{\text{age}}{12 + \text{age}}$ formula, or one based upon weight, will give a dose two or three times too large for children under two years. On the other hand, in excessive pain, peritonitis, obstruction of the bowels, and flooding, three or four times the usual dose may be given to adults. Liquid preparations are absorbed by the rectum almost as quickly as by the stomach, and act more locally; a slightly larger dose suffices. Suppositories are somewhat slower, and require a double dose. When quick relief is desired, or the stomach is irritable, or the appetite bad, it is best given hypodermatically, care being taken to avoid a vein. The location is usually not important so long as a place where the skin is rather loose and the circulation active is chosen. The fore or upper arm, leg, or thigh are usually chosen; but sometimes, as in neuralgias, a specially quick and effective result is obtained by injecting in, or over, the course of the nerve, a practice frequently followed in sciatica. A slightly smaller dose than by stomach suffices. A solution may be made and preserved as above for this purpose, or the "hypodermic tablets" made by several manufacturers may be used, or the powder may be dissolved extemporaneously. In liniments, ointments, and washes, although less useful than would be thought, it is still of considerable local power.

Hydrochlorate of Apomorphine (*Apomorphinæ Hydrochloras*, U. S. Ph.) is the most remarkable and efficient emetic at the command of the physician, and should be always at hand for occasions where quick vomiting is desired. It should be given hypodermatically, for which the hypodermic tablets are convenient. Dose, from five to ten milligrammes (gr. ⅛ to ⅙).

Allied Plants.—There are upward of a dozen species of *Papaver*, mostly natives of the Old World. Several are cultivated for ornament; two or three have been shown to yield minute quantities of Morphine. *P. Rhœas* Linn., the corn-poppy of Europe, is valued for its brilliant scarlet petals, which are generally official abroad (*Petala Rheados*, Br. Ph., etc.). They contain an alkaloid (*Rheadine*) of no very special qualities, and one or two coloring substances. The syrup from it has a beautiful color, and is used for that, as it has no active properties. The order (*Papaveraceæ*) contains also *Glaucium*, *Sanguinaria* (Blood-root), *Chelidonium* (Celandine)—a group of active character, but of little or no therapeutic value, and the pretty Californian *Eschscholtzia*.

Allied Drugs.—Poppy-capsules are still sometimes prescribed. They are the heads or pods of the Opium-poppy, generally of the variety *album*, collected, without scarifying, just before they are ripe, and carefully dried. Those produced in England are larger and fairer than those of the Continent. They generally contain a "little Morphine." From poppy-seeds a useful oil is extracted. The nearest approach to Opium in physical character and appearance is Lactucarium, or "Lettuce Opium," which

is collected in an exactly similar way. It has some soporific power, but is not reliable. Cannabis Indica may also be mentioned as well as Hops. The anæsthetics—Chloroform, Ether, Nitrous Oxide, etc.—will allay pain equally with Morphine, but usually not until consciousness is very much impaired. Jamaica Dogwood (*Piscidia Erythrina*) appears to have some power over pain, and as a hypnotic. Some other stupefying agents produce similar results, but not satisfactorily. There are better medicines as pure hypnotics than Opium—Chloral, Paraldehyde, Urethane, Hyoscine, and the bromides may be mentioned; they are frequently used as adjuvants to Opium or its alkaloids. The same may be said of Atropine which, by counteracting some of its effects, is occasionally useful when given with it. *W. P. Bolles.*

OPIUM HABIT, THE. Nature is ever emphatically reminding us that we must not abuse the powers for good which she places in our hands. Alcohol, which has unquestionably been the means of saving many from death through either exposure or wasting disease, may, when used injudiciously, prove an unmitigated evil, carrying only misery and destruction in its path. And opium, which, in the treatment of many diseases, is the physician's sheet-anchor, and which is absolutely indispensable in the treatment of acute inflammatory affections, may, in the hands of the thoughtless and weak, become a curse to the individual, and even threaten the moral degradation of an entire nation.

History.—The opium habit appears to be a disease of comparatively modern times. The drug itself was undoubtedly used in ancient times, for we find allusions to it in Homer, Ovid, Pliny, and Virgil. Hippocrates, who practised medicine four hundred and fifty years before the Christian era, alludes to it; and Galen, who flourished in the second Christian century, considered it of importance. Nowhere, however, among the ancient writings which have come down to us, or among the inscriptions found on Egyptian ruins, do we see anything indicating its use as a stimulant and intoxicant such as we notice in modern times. It is very probable that a compound of certain drugs, such as opium and cannabis indica, may have been used to a slight extent among the ancient Greeks and Romans for purposes of stimulation, but I think we may safely say that the pure drug was never used by them to the extent and after the manner of modern habitués.

In the Middle Ages and during modern times Turkey and Persia have been the great centres both of the culture and of the intoxicant consumption of the drug. It was said to have been carried from Turkey into other countries by the spread of Islamism. Of this, however, but little is known, and for many centuries after the extension of Mohammedanism in the East we have but meagre records of its consumption. We first hear of the drug in India about the year 1511. According to Shah Abbas, opium was carried into China by the Tartar tribes in 1644. But at this period, and probably for a century later, it was used in those countries chiefly as a medicine. It is very likely, however, that the people of China and India were slowly acquiring a liking for the drug, especially those of the former country. In 1767 a Mr. Watson, who was probably familiar with this increased and yearly increasing consumption of the narcotic, suggested to the East India Company the desirability of shipping opium into China. Previously to this date the Portuguese, who had bought opium in Turkey, had carried on a small trade with China, amounting to two hundred chests yearly. Mr. Watson's suggestion was like the springing of a fatal trap. Immediately the consumption became enormous. The East India Company found a bonanza, but at the cost of untold misery to the Chinese nation. The habit became so universal and the consequences so deplorable that in 1796 Kien Long legislated confiscation of goods, and even decapitation, for those who indulged; but all to no purpose. In 1820 the Chinese Government again tried to check the trade by legislation. This attempt also proved ineffectual; the native merchants refused to co-operate with the laudable efforts of the government to correct what had become a national vice, and the English persisted in landing the drug. In 1839 the Emperor Taou Kwang hoped to put an end to the trade by ordering the wholesale destruction of all the opium in the hongs. At this time 20,283 chests were washed into the sea. The result of this edict was the so-called Opium War. Again, in 1860, the English forced the Chinese to legalize the traffic. From this time to the present the vice in China has been a national one. India has become the great opium market of the world, and, as Calkins says, Hindostan may be called "an immense poppy garden."

For nearly forty years the opium habit has been developing in the United States. In 1843, Wood, of Edinburgh, devised the hypodermatic method of injection, which was not really perfected until some years later. Previously to this discovery opium was used either in the form of the gum or of one of the alcoholic preparations. Since the hypodermatic method has become generally known the consumption of the drug, both in Europe and in America, has greatly increased. For years previous to this discovery the habit was limited to a comparatively small proportion of the population of these countries. But latterly the convenience with which it can be administered, the diminution of bulk, and, perhaps more than all else, the increased number of neuroses among the people of England, France, Germany, and America, the diminished power of resistance to pain, physical and psychical, and the consequent increased demand for some powerful nerve-stimulant—all these things have contributed to the marked increase of the habit in these countries.

Among Oriental peoples the habit has been rather the result of a desire to gratify a purely sensuous appetite. They have indulged in opium, not so much for the sake of relieving physical and psychical pain, as for the enjoyment of the pleasurable intoxicating effects of the drug. And there is much evidence to show that the people of the Orient are affected by such indulgence in a manner very different from that observed in the case of the inhabitants of the temperate zone. Among Eastern nations smoking has been the favorite method of bringing the individual under its influence. The habit of smoking opium was brought into this country by the Chinese. In 1868, according to Kane, the first American, a low, sporting character, indulged in the use of the pipe. He induced others of his associates to try its stimulant effects, and in the short space of eight years the habit of smoking had become so general on the Pacific coast that the authorities were called upon to exercise their influence against its degrading effects. Large, however, as has become the number of opium-smokers (their number in this country, aside from the Chinese, Dr. Hamlin states is 20,000), they are confined chiefly to the large cities, and the particular vice is still a more purely Oriental one, and is as yet carried on under the direction and management of Chinese proprietors.

Etiology.—Among Europeans and Americans the opium habit is chiefly initiated by the use of the drug for the purely legitimate purpose of relieving pain. And hence it is that the patient often dates his first indulgence back to the physician's order.

If the latter were to keep the drug in his own hands and use it as any other medicine is used, he would not so often receive the charge of initiating his patient in the indulgence of a pernicious habit. But too often it happens otherwise. The physician, either on account of pressure of business or from a desire to avoid increased expense to his patient from so many visits, transfers the administration of the drug to the patient himself. He teaches him superficially the laws of its action, its dose, and even provides him with a syringe and instructs him in the hypodermatic method. What wonder, then, that it often results that the physician has placed a weapon in the hands of his patient worse even than the disease he wishes to subdue? Over seventy-five per cent., probably, of all cases of the opium habit in this country, on the Continent, and in Great Britain, originate in the way just mentioned. The rest are led into the habit either for the purpose of in-

dulging in a purely sensuous enjoyment, to which class belong the opium-smokers, or they contract the habit through inability to resist and control an appetite which is, unfortunately, the outgrowth of a feeble organization transmitted to them by heredity. Though of less frequent occurrence than chronic inebriety, still a chronic opium habit, due to defective will-power and to all the weaknesses transmitted by neurotic vice, is by no means uncommon. Nearly every asylum contains, side by side with inebriates, chronic morphinists, the only reason for whose habit seems to be a defective and demoralized will-power, which, in turn, is directly traceable to some inherited neurotic taint. One case, recently under the writer's observation, presents a suggestive family history, and will serve as an illustration of what is frequently met with in analogous cases. The young man, about thirty years of age, had been addicted for some years to the use of both alcohol and opium, and had become so completely demoralized by the use of the latter that residence in an asylum became necessary, not only for his own safety, but for that of others. His family history presented the following facts: Maternal grandmother, an opium-eater; paternal grandmother was insane, and died of phthisis; paternal grandfather, a hard drinker, and died of phthisis.

Undoubtedly the invention of the hypodermatic syringe has done much to increase the prevalence of the opium habit. The results are so rapid, and the relief of uncomfortable sensations so instantaneous, that the instrument seems in a very short time to exercise a strange charm over its victims. There seems a fascination in the very thought that the patient can in an instant stimulate every fibre of his being, and transfer himself to a condition in which he seems superior to all the petty ills by which he is surrounded when not under its influence. The rapidity and ease with which the transition is effected through the agency of the syringe is unquestionably one of the causes of the constantly increasing and alarming prevalence of the morphine habit.

Pathology.—The morbid anatomy of the organs of the opium-habitué is at present but little understood. At least, insufficient data have been collected to prove of any great value. There is but little doubt, however, that the ultimate results of the habit, which we find principally in the gastro-intestinal tract and the kidneys, are effected through some pathological action of the drug on the cerebro-spinal, sympathetic, and central nervous system. As yet we are ignorant of what changes do take place in these nerve-tracts as a result of the habit. Probably they are, in large degree, similar to the changes produced upon the same system by alcohol or other stimulant, and are degenerative in character. Experience would seem to teach that the great nerve-centres tolerate stimulation only up to a certain point; beyond that they weaken, lose their normal and healthy action upon other tracts and organs with which they are physiologically connected, and ultimately, if the artificial stimulus is not removed, undergo retrograde changes.

The gastro-intestinal tract is generally among the first to suffer from indulgence in the habit; but the changes effected here are only secondary in character, and due to primary changes in the nerve-centres supplying the glands and blood-vessels of this region. Thus there is always found in the stomachs of opium-habitués a chronic gastric catarrh, with the characteristic lesions of that disorder. This gastritis is, however, secondary. Opium, through its action on the nerves supplying the glands of the stomach, checks their secretion; this delayed and diminished secretion of the gastric juice causes imperfect and delayed digestion. The ingesta pass through the stomach in a half-digested state, and produce the usual consequences of congestion and subsequent hypertrophy of cell-structure. The same results occur in the intestine. Levinstein's very interesting experiments on animals illustrate perfectly how opium paralyzes the action of the gastric glands. Two pigeons, one of which is dosed with morphia, and the other is not, are both fed with an equal number of peas. In the course of a few days they are killed. The pigeon treated with morphia presents a stomach filled with half-digested peas, and the mucous membrane of which is swollen and congested; the other pigeon's stomach is empty, and the mucous membrane is entirely normal in appearance.

The most constant pathological action of opium is this paralyzing of function in the various secretory glands. As has been said, this is due to some previous morbid changes produced in the nerve-tracts supplying these glands. We may witness this same effect in the sebaceous, mammary, and salivary glands, in the ovaries and in the testicles. The normal secretion of each is checked, and, therefore, in habitués we find diminished secretion, with consequent impairment of function in these several glands. When opium is taken in minute doses, and for the first time, there is exhibited a stimulant action, and very likely at this period there may be a slight congestion of the several glandular organs. Experiments on animals show that under the influence of morphia the kidneys are much congested, and probably on this account there is greater or less secretion of albumen in the urine. But the ultimate effect of opium is to paralyze normal glandular action, and hence to diminish the various secretions. This has an importance, as we shall see, in explaining many of the symptoms occurring in sufferers from the opium habit.

Symptoms.—As has been stated, opium is essentially a stimulant, and in this respect offers some slight analogy to alcohol. Some writers, as Calkins, even suggest that its use may be in a large measure supplanted by alcohol, and cites Turkey as an example of a country where indulgence in wine has increased while that of opium has decreased. However this may be, it is certain that opium does possess the property above mentioned. It was for this subtle, stimulant action that De Quincey was in the habit of taking his potion on a Tuesday night, and, while under its influence, of revelling in the pleasures of the Italian opera; and again, on a Saturday night, after indulging in the customary draught of laudanum, he would sally out into the labyrinths of the London streets, visiting the market-places and by-paths of the great city. No one knew better than he the primary stimulant action of the drug, for he says: "Certainly opium is classed under the head of narcotics, and some such effect it may produce in the end; but the primary effects of opium are always, and in the highest degree, to excite and stimulate the system."

As in the case of all stimulants, there is a limit to the amount of endurance or toleration which the system can entertain for them. This limit marks, in a pronounced manner, the beginning of the pathological symptoms in the individual. The tolerating limit of the individual, and likewise the inception of his real trouble, varies with the person. Idiosyncrasy plays a most prominent part in the symptomatic history of the opium-habitué. The drug affects different persons differently; some possess a wonderful toleration for it, taking it for years without serious injury to the health, while others succumb to its action in a few weeks, or, at most, months. I have known an individual to take for years a dose of Macmunn's elixir, varying from seven to twenty drops, and to be dependent upon it for sleep and comfort, and yet never be compelled to go beyond this amount; nor did he, indeed, experience anything but good effects from it, so remarkable was his toleration of the drug.

Ordinarily, the person who has taken the drug constantly, day by day, begins to be affected with the characteristic symptoms of the opium habit, or morphia hunger, in from two to six months. In a general way, Oriental people tolerate the opium habit better than those of temperate climates; they seem less susceptible to its stimulant effects, and yield rather more readily to its narcotic action. De Quincey, whose writings on this subject are too imaginative to possess much scientific value, illustrates very vividly, however, the peculiar action of opium on different temperaments in his article on the "Pleasures of Opium," where he contrasts its action on his own sensitive organism with its influence on the more unintellectual and unimaginative Turk.

One peculiar fact is worthy of notice at this point.

Notwithstanding that individuals vary so greatly in the size of the dose that can be borne by them, it is seldom that an opium-habitué is poisoned by the drug, unless he take it with deliberate suicidal intent. However large his dose may be, there is a limit beyond which the person cannot go. When this particular maximum amount has been reached, he stops instinctively. Some attain this limit when they have taken from two to five grains of morphia per day, or thereabouts; others, when they have taken so enormous a quantity as sixty or even seventy-two grains of morphia per day in three doses. Among smokers the amount of opium consumed is much larger than by any other method, for the reason that a less quantity is really absorbed into the system. There is a large amount of waste in the ash left in the pipe; so much so, that this very waste is saved and worked over into a new but inferior mass. Smokers consume about six grains of the drug at first, and increase from this amount to from sixty to even three hundred grains per day. The habit is therefore an exceedingly costly one, and to this extreme extent can be indulged in only by those of the wealthy class.

After a person has taken opium for a longer or shorter time, he begins to feel a more or less imperative demand for the drug as the influence of the last dose wears off. Especially is this the case when the individual has been in the habit of taking an allowance at a certain definite time. As this time draws near he begins to feel somewhat nervous and uneasy; he may have sensations of chilliness; he will, perhaps, experience a desire to yawn and stretch himself; not infrequently he may suffer neuralgic pains in different parts of the body or extremities. If the administration of the drug is delayed, perspiration may appear, and even become profuse, or a feeling of nausea will torment the person. A sense of fatigue or extreme prostration may occur. To whatever extent these symptoms may show themselves, there always occurs an indescribable longing for a fresh dose after the stimulant action of the previous indulgence has passed away. A lady patient once said to me in reply to my interrogations on this point: "I cannot explain my feelings; I can only say that my whole system seems to long for morphia just as one longs for food when hungry." All these distressing symptoms vanish when a fresh dose is taken.

After a longer or shorter time, which varies with the idiosyncrasy of the person, it is found that the same amount of the drug that has hitherto sufficed fails to bring the accustomed relief. An increase is necessary. This increase is repeated, and soon it results that what would at one time have been a poisonous amount is now not only tolerated, but is absolutely indispensable to comfort. Long, however, before this greatly increased dose has been reached, the individual begins to present certain physical symptoms which indicate a very marked deterioration of bodily health and show the profound influence that the drug has exerted upon the nervous system.

Chief among the organs to be affected is the stomach and, by virtue of its close relationship to that organ and its partial similarity of function, the intestinal tract. In speaking of the pathology of the opium habit, allusion was made to the impaired digestion, and its explanation was assigned to a diminished activity in the glands secreting the gastric juice. This imperfect action of the stomach, attended as it is by faulty assimilation, exerts a marked depressing influence on the entire animal economy. The usual symptoms of malnutrition show themselves. The red blood-corpuscles diminish in number. The person becomes sallow and his complexion acquires a pale, ashy hue. The appetite fails. Nausea is a frequent symptom. The muscular system becomes flabby, and the power of endurance is greatly diminished. The thickened state of the lining of the stomach and duodenum causes a partial occlusion of the bile-duct. Absence of bile and of secretion from the intestinal glands, due to their paralysis through the action of the drug on the nerves supplying them, causes an obstinate constipation. This latter symptom only seems to increase the uncomfortable sensations and intensify the morbid phenomena set in action by the impaired digestive functions of the stomach. The absence of bile in the intestines also causes a greater or less decomposition of the ingesta, and this, in its turn, develops another source of irritation. The imperfectly digested and partly decomposed food produces flatulency and eructations, and frequently, as a still further result, an irritative diarrhœa alternates with the obstinate constipation.

The respiratory tract is not as profoundly affected as are the digestive organs. Occasionally there is catarrh of the pharynx and larynx, more often seen among smokers than among those who take the drug by the mouth or subcutaneously.

The opium or morphine habit exerts a varying influence upon the kidneys. According to Levinstein, among persons addicted to the use of morphine, albumen is found at times in the urine; at other times chemical analysis does not detect it. The same author asserts that sugar is never found except when the drug is taken in poisonous doses, and that then it is always found. Kane, however, asserts that he has found sugar in the urine of four patients; that in one of these cases it was permanent, that it came and went in the other three, and that in three of the cases it disappeared after the morphine had been stopped. Bartholow, on the other hand, does not consider that cases of albuminuria and diabetes that are met with in this country "are due to the subcutaneous use of morphia." In one case only of those that have come under my observation have I found sugar. But it appeared after the morphine had been entirely removed; and, occurring as it did in an old opium-habitué whose general health was much debilitated, it may have proceeded from other causes.

The physiology of the albuminuria of opium-habitués is not clearly understood. Levinstein advances, as the most probable theory of its occurrence, the varying blood-pressure in the vessels in the kidney. Its occasional disappearance and reappearance is certainly more easily explainable on this theory than on any probable effect produced by the drug on some albumen-centre in the cerebro-spinal system. As yet, however, our data are too limited to admit of any very satisfactory explanation of the pathological fact. The albuminuria, however, does not depend on any structural disease of the kidneys, for it entirely disappears, although sometimes very slowly, after the use of the drug has been discontinued. Occasionally, but rarely, casts and renal epithelium have been found in the urine of opium-habitués; but, inasmuch as they have entirely disappeared on the abolition of the habit, it is safe to say that there was no structural disease of the organ. Here, again, the most plausible theory is that the drug causes a varying blood-pressure in the renal vessels, and by virtue of this greater or less vascular tension produces the chemical and microscopical changes noticed in the urine. Indeed, we frequently see, in other bodily conditions, how changes in arterial tension produce exactly the same temporary results in the renal secretion.

These morbid changes of the circulation, the effects of which we have just seen in the kidney, are frequently observed in the skin. There occurs congestion of the face, producing flushing, which is often followed by perspiration. Frequently there are flashes of heat in different parts of the body, which may, in all probability, be caused by a varying blood-tension. A quite common and very troublesome symptom among those who have carried the habit to excess is profuse cold sweating, due to relaxation of the blood-vessels following their previous tension. In advanced cases there are sometimes seen spots of purpura. The slight, dropsical effusions also testify to the deteriorated state of the blood, which admits of the transudation of its watery elements through the vascular walls into the cellular tissue.

Another symptom, which was first noticed, I believe, by Levinstein, is a periodical fever similar in character to the intermittent fever of malaria. This peculiar symptom has not been known to follow the habit of smoking, but has been generally noticed among those who use the drug hypodermatically. Its pathology is not clearly understood. Levinstein thinks the fever due to a certain neuropathic constitution. Bartholow con-

siders that the attacks are "usually associated with an acute gastro-intestinal catarrh, and are preceded by constipation and a much overloaded colon." He also says that they rarely occur in winter, more frequently in summer and fall; that they are generally irregular, and, though sometimes quotidian, they may assume the remittent type. Levinstein affirms that the tertian type is the most common. During these attacks the temperature may rise as high as 104° F. Quinine produces only the most transitory, if any, effect. An increased dose of morphine will almost always relieve the patient, but relief thus produced is only followed by an aggravation of the symptoms. Permanent withdrawal of the drug, however, always puts an end to the chills. This efficacy of the withdrawal of morphine, the irregularity of the attacks, the fact that the person has never been exposed to the malarial influence, and the inefficacy of quinine, are the only diagnostic points by which we can distinguish the chills from ordinary malarial intermittent fever.

Severe neuralgias are often associated with this variety of intermittent fever. But the most serious feature of these attacks is the great physical prostration that generally accompanies them, and the danger of collapse that is liable to occur during the height of the attack, in the severe cholera morbus that may accompany it, or in the profound prostration caused by attempting to remove the drug itself too suddenly. The very attempt to cure the disease may prove dangerous itself.

Upon the reproductive system, as upon other glandular organs, the opium habit exerts an injurious influence. When the drug is taken in small doses, and at the commencement of the habit, it frequently has a primary stimulant action. This effect is often witnessed among those who smoke as well as among those who take the drug by other methods. This sexual stimulation is, as a rule, of short duration, and as soon as the habit has become confirmed, and the dose has reached any size, the ovaries and the testicles begin to lose their normal action, and, if the habit continue, may suspend their functions entirely. This effect is in nearly all cases functional, and structural change in the glands does not occur except in extreme cases, among those who not only indulge in the habit themselves, but who are descended from parents addicted to the vice. Ordinarily, when the habit is given up, the glands resume their normal activity. Menstruation reappears in the female, and erections and involuntary emissions recur in the male.

Race and individual idiosyncrasy doubtless play a prominent part in this action of the drug on the reproductive organs. The Turk and the Chinese probably suffer less in this respect than the inhabitant of temperate climes; but among the latter we do find some individuals of either sex whose sexual functions are but little impaired.

Among women subject to leucorrhœa this discharge is often known to cease while they are indulging in the habit, but it reappears as soon as the drug is left off. Quite frequently women who are taking large quantities of opium conceive, but miscarry at some period of their pregnancy. Levinstein mentions, as a somewhat curious and noticeable fact, although he does not consider it by any means constant, that young and healthy women, themselves not addicted to the habit, have not gone through the full term of their pregnancy after their husbands became habitués; and this notwithstanding that they always were delivered at full term previous to the time when their husbands acquired the habit.

The same author, in his experiments upon pregnant animals, found that their mammary glands shrank in size, and that in nearly all cases they gave premature birth to dead young. He draws the following conclusions from his experiments: "In cases of amenorrhœa due to morbid craving for morphia, the growth of the ovarian cells would be stopped from one monthly period to another, and consequently there would be a want of the stimulus on the ovarian nerves, causing, on the one hand, the rupture of the Graafian follicles, and producing, on the other hand, a congested state of the generative organs by reflex action. Hence the morphia would act in the same manner on the ovaries as on other secreting glands—*i.e.*, would render them devoid of functions under its continued influence. It is likely, therefore, that the menstrual discharge does not show, on account of no ovulation taking place; this, also, would account for the sterility."

We have seen that opium exerts a profound effect upon the nervous system. In fact, there is where its chief pathological action is seen—its influence upon organs and glands being purely secondary, and the effect of disturbance wrought by the drug on the nerve-tracts supplying those parts. We cannot feel surprised, therefore, to learn that its pathological action extends to the higher nerve-centres in the brain, and that the mental and moral faculties are quite frequently disturbed by a prolonged use of the drug.

Here, again, we find occasional, although not always constant, evidences of a primary stimulant action. There are persons whose mental faculties are buoyed up by the drug who experience that subtle exhilaration of mind that wine occasions in others. Nearly every physician whose practice has extended to opium-habitués will recall cases illustrating this greater or less stimulant action upon the intellectual centres. While under the influence of the drug they exhibit a loquacity and vivacity of word and action which is in marked contrast with the depression attending their periods of abstinence. There are cases on record of society ladies who have spent most of the day in bed, who, under the influence of opium, have figured in the evening in brilliant literary and social circles, and whose brilliancy of conversation and repartee depended wholly on the stimulant action of the dose of morphine or laudanum. Such extreme cases, however, are of infrequent occurrence, and generally the secondary effects of the drug are soon seen after a constant indulgence.

Opium primarily produces functional derangement of the mind. When the person gives up the habit, the mind returns to its normal condition. But when indulged in for years, opium may produce a permanent deterioration of the mental and moral faculties, and this permanent deterioration is undoubtedly due to an organic degeneration of the cerebral centres.

The question of the mental and moral responsibility of those addicted to the opium habit merits consideration at this point. It is obvious that a person who is suffering from mere temporary and functional mental disturbance—the result of a single or a number of opium debauches—is practically in the same condition as the drunkard, who, while under the influence of alcohol, labors under a temporary mental alienation. The law, however, holds the drunkard responsible for any acts he may commit while in this state of temporary mental confusion, for the reason that the person voluntarily places himself in this condition while he has control of his faculties. In like manner, the opium-habitué voluntarily indulges an appetite of which he knows the consequences, and hence, while under its influence, would be held responsible for any indiscretion he might commit. The existence of the habit would not legally incapacitate, therefore, a person addicted to it. Obersteiner, in an article on "Chronic Morphinism," in *Brain* for January, 1880, records the case of a young man who attempted to evade the legal punishment of theft by reason of his being a morphinist. He declared that on account of his habit "his cerebral blood-vessels were so congested that his ideas of things were perverted." The accused was unable, however, to prove that he was addicted to the habit, and the police-surgeon demonstrated that he was simulating the symptoms of morphine hunger. The case is instructive, as showing how dangerous would be the precedent of extenuating crime committed by persons while under the influence of a degrading habit.

Lähr and Fiedler have even gone so far as to assert that craving for morphine is in itself a mental alienation. Facts would scarcely seem to support this theory. Too many evidences everywhere exist of the highest intellectual attainments and the most perfect co-ordination of thought and action occurring in persons who not only

take the drug, but who are at the same time under its influence. In the great majority of cases the opium indulgence is simply the unwise yielding of the individual to an artificial appetite, and does not necessarily presuppose any morbid diathesis. Occasionally cases are met with of individuals who seem to have an inherited vice of constitution, which manifests itself in neuroses, and which often seems to impel the individual to indulgence in stimulants or narcotics. Asylum records often present lamentable histories of families, the various members of which show a record of phthisis in one, chorea or epilepsy in another, insanity in a third, and in still another an uncontrollable dipsomania which seems to recognize no bounds, or a morbid and equally reckless abandonment to the opium habit. Unquestionably, in these cases there is a constitutional vice to begin with, which renders the individual more or less irresponsible for the morbid appetite. Ordinarily, however, the opium habit is not acquired in this way, but occurs rather in persons whose minds are perfectly healthy and who contract the vice after first using the drug as a medicine.

As among drunkards, we find also that opium-habitués may experience delirium tremens. This delirium is generally of an acute character. It appears when the drug is withdrawn suddenly. It is of short duration, generally disappearing in twenty-four or forty-eight hours, even though the appetite is not gratified. The patient may become violent and maniacal. He will have hallucinations of sight and hearing, and may become destructive and violent in his actions and incoherent in his speech. The attack will generally subside itself, leaving the patient in a confused and exhausted condition. Quite frequently he has no recollection of the transitory excitement through which he has passed. The chief diagnostic points between the delirium of morphinists and that of drunkards is the short and essentially self-limited character of the former. The administration of morphine will generally check the attack, while the delirium potatorum is often intensified by the taking of liquor. Delirium potatorum may result fatally, while that arising from the morphine hunger rarely culminates thus.

There is a certain class of opium-habitués, young men, chiefly of the kind possessed of feeble will-power and morbid imaginations, among whom there often occurs a general mental and moral deterioration very similar to what one sees among inebriates. And a description applying to the latter will likewise answer for them. There is in them a loss of self-respect, a most persistent and shameless mendacity, a weakening of the will-power, and an entire disappearance of a healthy ambition. Not infrequently in these cases the moral faculties become perverted, while the intellect remains intact. Such persons will lie and steal, and display a maliciousness that is truly remarkable. Thoroughly demoralized themselves, their sole ambition in life seems to be to make themselves as mischievous as possible, and to give as much anxiety to their friends and relatives as lies within their power. Frequently their nearest relatives establish them in business and make great sacrifices of time and money to place them in a respectable position in life. It is all without avail; they soon renew their old habits, and disgrace themselves and their families without compunction. Finally, after every argument that love and self-respect can command is brought to bear upon them, after every resource has been tried in vain, their relatives lose all patience, and as a last resort endeavor to commit them to some hospital for the insane, where they may be placed under some restraint without having the disgrace of the penitentiary attached to them. No class of patients can be more unwelcome to hospital officers. Their influence upon their fellow-patients is uniformly bad, and the restraint upon their liberty only tends to aggravate them the more. Unfortunately there has been very little legislation in regard to this class, and consequently the commitment of such patients to asylums is unsatisfactory in the extreme. Generally they are self-committals, having been induced by their relatives to take such step; but a few weeks' residence at the hospital renders the place odious to them, and, being under no legal restraint, they cannot be detained. As this class, both of opium habitués and inebriates, has already become considerable, and even includes both sexes, it would almost seem imperative that there should be some legal provision in the different States which will cover these unfortunate individuals. It is somewhat singular that Benjamin Rush should have felt and anticipated this need so many years ago. He recommended the establishment of hospitals in every town in the United States for the reception of hard drinkers. In his day the opium habit had not assumed its present proportions, or he would doubtless have included its victims among those for whom provision should be made.

He wrote: "They are as much objects of public humanity and charity as mad people. Let it not be said that confining such persons in a hospital would be an infringement upon personal liberty incompatible with the freedom of our governments;" and he added, that such persons "should be committed by a court consisting of a physician and two or three magistrates or commissioners appointed for that purpose."

In this connection it is interesting to notice that the Massachusetts Legislature has recently passed an act intended to apply to this very class, but not to opium-habitués.

It is to be hoped that similar laws may be passed in other States, which will sanction the commitment of both inebriates and morphinists to asylums or other suitable places. It is questionable whether insane asylums are the proper places for detaining these unfortunate persons. The influence of either class upon the other is bad. The victims of a morbid appetite, in their association with the insane, tend to make that class dissatisfied and restless, by filling their minds with ideas of unjust confinement; and the very fact of their sanity seems to add a certain weight to their specious arguments. But, however questionable the legal confinement of inebriates and opium-habitues in asylums may be, there is no doubt that legal detention somewhere is advisable.

There is still another form of mental deterioration which is apt to occur in those who have taken opium or its alkaloids for years. The mental disturbance is of a chronic character, and indicates a general weakening of brain-power. The change is analogous to what one sees in chronic drunkards, and probably is occasioned by a gradual organic deterioration of the brain-cells. The general mental impairment persists after the drug has been removed, and even though the habit has been discontinued for years. Such persons become forgetful and unambitious; they are apt to think well of themselves, and often tell incredible stories of what great things they have accomplished. They lack energy, and, though formerly of keen intelligence, lose their intellectual acuteness. In extreme cases there may be delusions of suspicion and fear, such as one sees occasionally among old drunkards. I have never met with such extreme chronic mental disturbance among morphinists, but Levinstein speaks of cases of chronic delirium tremens in which there are delusions, depression of spirits, and nervous trembling of the hands. He attributes this state to a chronic poisonous action of the drug acting upon the system even after its use has been discontinued. Chronic mental impairment, due unquestionably to organic cerebral deterioration such as is witnessed in cases of chronic alcoholism, is what we usually see.

Prognosis.—The prognosis of the opium habit is not particularly favorable. The accumulating evidence of later experience rather contradicts the more hopeful views that were entertained in the early days of its introduction. The alarming prevalence and increase of the habit dates back scarcely more than a quarter of a century. Many cases in the early records of observations have undoubtedly proved to have had relapses, and a great many cases recorded and discharged from institutions as "cured" cannot safely be registered as such. Such a strong element of deception has entered into nearly every case of well established opium habit that we can place but little reliance upon the patient's word. I am

convinced that many cases, with every protestation of a desire to recover, and even in spite of the fact that they have voluntarily placed themselves in institutions at their own expense for the express purpose of breaking off the habit, will, nevertheless, deceive the physician and surreptitiously indulge their craving for the drug. Many cures are apparent, therefore, and not real; and there is always a danger of relapse in those whose cures have seemed most perfectly established. The circumstances which may lead to a relapse are oftentimes so slight that the patient, with even the best resolutions, finds himself brought face to face with his old enemy. I have known many cases, who considered themselves cured, take unwittingly a fraction of a grain of morphine in the prescription of a physician who was ignorant of their weakness, and find themselves totally unable to resist the terrible impulse to indulge again and again, until, to their dismay, they were once more completely in the power of their old habit. A person who has once become a slave to the habit can never afterward with safety indulge in the minutest fraction of a grain. A certain dominant pathological longing seems to be awakened in every part of the nervous system, and the demand is simply irresistible.

Certain conditions affect the prognosis. These are :

1. The length of time a person has indulged in the habit.

2. The existence of some neuralgic, rheumatic, or other painful affection, which not only operates as a cause of the habit, but which is continually urging the patient to a further use of the drug.

3. The existence in the individual of a certain inherited dyscrasia, by which he becomes a victim to a morbid craving for stimulants.

The first condition scarcely requires more than a passing allusion. As with all other habits, the longer the individual has indulged himself the more firmly fixed does the appetite become. In fact, it comes to be incorporated, as it were, in the very cell-structure of his nervous centres. An undefinable and powerful longing has in some way been established there, and hence the diseased appetite, habit, or whatever we may choose to designate it, oftentimes has a more material basis than we may at first suspect. And so, literally, though the spirit may be willing, the flesh is very weak. I am forced to the somewhat sad conclusion that there comes a time in the life of every opium-habitué when the breaking of the habit is next to impossible. The duration of the habit and the effect that this has had upon the individual become, then, prominent factors in the prognosis.

The second condition affecting our prognosis is self-evident. Many a person might break himself of the habit were it not for the fact that some painful affection, such as rheumatism, cancer, or neuralgia, and which probably first induced him to take the drug, still holds him as in a vice. We should bear this fact in mind, however, that chronic painful affections admit of the individual tolerance of the drug to a very marked degree. Pain is always an antidote to opium and its alkaloids. Hence in chronic maladies of a painful character, provided the physician himself will direct the administration of the drug, there is less danger.

The third condition of prognosis is most hopeless of all. Transmitted dyscrasiæ and transmitted morbid appetites are most persistent and least easily curable. Occasionally the neurosis and the disease alternate in different generations. The parents may be drunkards or morphinists, and the children insane, or *vice versa*. Vicious appetites and the various neurotic disorders are closely allied in their etiology, which is generally found to be a state of faulty nutrition of the nervous centres and tracts. A weakened nervous system, a defective will-power, carrying with it diminished resistance to morbid appetites and tendencies, would be, then, a strong factor in the prognosis of this or that case of opium habit, and whenever this faulty diathesis does appear the prognosis is always bad.

Our prognosis may, then, be favorable, provided the individual has not indulged his appetite for too long a period and has no painful, chronic, or recurrent malady necessitating the use of opium, and especially if there is no previous hereditary history of intemperance, insanity, or other allied neurosis. And this, too, notwithstanding the fact that the amount taken may be very large. Individual tolerance of the drug varies so greatly, according to personal idiosyncrasy, that we cannot prognosticate unfavorably of a case simply because the dose attained has been a large one.

Treatment.—It is a curious fact, that among those accustomed to the use of opium any attempt to reduce the dose produces the same symptoms which are often relieved by a small dose among those unaccustomed to its use. Thus pain, insomnia, depression, restlessness, vomiting, diarrhœa, are generally relieved by a fractional dose among the uninitiated, while identically the same symptoms are manifested in the habitué who attempts to omit or rapidly reduce his usual allowance. It seems as if opium, taken for a long period and to excess, will establish in the system the very condition of things which at another time it will relieve. It is also a noticeable fact that opium has a more excitant effect upon persons of nervous temperament. It is important to bear these effects in mind when undertaking the treatment of the opium habit, for one or all of them are liable to appear when any attempt is made to reduce the amount taken.

Two methods of treatment have been suggested : The *sudden deprivation* and the *gradual reduction*. Levinstein has been the chief advocate of the sudden-deprivation method. His arguments in favor of this treatment are as follows : "The complaints following upon every deprivation of the morphia are not of so violent a form when the drug is slowly withdrawn, but they continue for a longer period of time. After the sudden deprivation the patients generally overcome the severest symptoms in two or three days, while the others suffer for weeks together, not escaping any of the many symptoms following the abstinence.

"The human organization, as we know from surgery, midwifery, etc., will, in general, submit more easily to sudden and energetic treatment, even when acting powerfully, than to a milder influence. The gradual deprivation, requiring a long time, excites the physical and moral powers to a greater extent, because every dose smaller than the previous day's quantity will produce new symptoms of reaction. The constant mental anxiety in which these patients live, while expecting a smaller dose on the following day, makes them fretful and irritable—their intention of submitting till the end of the cure and their energy begin to decline, and they try to evade the treatment. They set up intrigues against the officials and nurses ; they simulate morbid appearances, in order to excite the pity of their relatives and friends ; they lose confidence in themselves and in their doctor, whose full and absolute authority is indispensable for the successful treatment of abstinence.

"In cases of sudden deprivation, on the contrary, the confidence in the medical adviser is strengthened in consequence of the short duration of the severe symptoms and the improvement already experienced after a few days ; the patients take courage, look forward to their complete recovery, and submit with patience and resignation to the few days of suffering." He excludes from this treatment all persons suffering from some chronic pathological complaint requiring the use of narcotics ; also persons "weak or exhausted from bodily or mental afflictions."

I quote Levinstein's words in full because they emanate from so distinguished an authority, and one who is the chief exponent of this method of treatment. Furthermore, the other method of treatment is so radically different that it is well to understand Levinstein's plan and the arguments both in its favor and against it. His own reasons for preferring the rapid reduction are certainly ingenious and specious, but are scarcely sustained by experience. In the first place, its extreme severity is a most potent objection. In the case of sudden deprivation the most violent symptoms arise, which show how profound a change has been wrought by the habit upon the

nervous system. A few hours after the withdrawal of the drug the patient begins to grow restless and nervous; he stretches and yawns, begins to have sensations of chilliness, has a kind of nervous apprehension, and cannot make himself comfortable in any position; consequently he walks about vainly trying to make his uneasiness more endurable.

Soon after this he experiences nausea, and a little later vomiting begins. This emesis, to which allusion has already been made and an explanation sought in the sudden removal of the gland paralysis which has been the result of the long continued taking of the drug, becomes a most alarming feature in the treatment. Everything that is taken into the stomach is at once rejected. In like manner, the salivary glands are thrown into activity; also the mucous membranes of the eye and nose. Profuse salivation, coryza, and sneezing, though not dangerous, are still most aggravating accompaniments of the sudden removal of the long-continued inhibitory influences of morphine. The same stormy reaction takes place in the intestinal tract. The glands, which have long been paralyzed by the systemic effects of the morphine, on its removal, find themselves suddenly thrown into activity; their nervous inhibition being removed, they doubtless become congested, and are forced into sudden and profuse secretion. This produces a constant watery diarrhœa, which does not admit of any checking except by the renewed administration of opium, or until the glandular apparatus and its nervous supply have regained their normal equilibrium through a sufficiently prolonged abstinence from the drug. But this constant diarrhœa, and the obstinate refusal of the stomach to retain food, is a source of profound danger. The patient grows weaker; his mind becomes affected, and he is thrown oftentimes into a wild, and almost maniacal, delirium which, in its turn, only still further weakens the exhausted nervous system and oftentimes initiates the next and most dangerous symptom, that of collapse. This collapse generally appears in the course of the second or third day of abstinence from the drug, and is itself, in my estimation, a sufficient argument against the sudden deprivation method of treatment. It is at times ushered in by a change in the voice, by a twitching of the facial muscles, by a trembling of the extremities; pallor and loss of consciousness soon ensue. Levinstein says: "The collapse may also appear suddenly, at a time when the severest symptoms of abstinence, such as vomiting and diarrhœa, have passed off, *and when we least expect such an occurrence.* The patients, while sitting in bed and talking to their attendants, at once become quiet, fall back on their pillow, and sink into a state of unconsciousness which cannot at first be overcome, even by the most powerful stimulants. The face sinks in and is of a death-like color. The nose is pointed, the eyes sunk in, the bulbi rolled up, the respiration is troublesome, retarded, and gasping; the pulse can only be counted while listening to the heart. . . . This condition may last from fifteen minutes to nearly an hour; it either recurs again three or four times during the twenty-four hours at short intervals, the patient in the mean time not entirely recovering his senses, or complete consciousness returns at once; or, lastly, as observed by Fiedler, death ensues, accompanied by symptoms of paralysis of the brain." It does not seem to me that any treatment thus jeopardizing suddenly and unexpectedly the patient's life can be justifiable.

The second objection to the sudden withdrawal of morphine from those who have become confirmed in its use is the extreme uncertainty as to the permanency of a cure which is supposed to be effected in so short a period as from three to eight weeks. Physiology has taught us that habits, whether of indulgence in stimulants or narcotics, lead, when continued for any length of time, to a certain organic change in the cell-structure of the nervous system. By virtue of this change, which is, of course, inappreciable by our present methods of examination, these same centres cease to act healthily or satisfactorily without the customary indulgence. No other artificial appetite produces such profound effects upon the nervous system as the indulgence in opium. Whether its effects are purely functional or not, it certainly revolutionizes the entire nervous economy of the individual, so that it can act only when he is under the influence of the drug. The least attempt to do without it is accompanied, as we have seen, by a general explosion within the great nervous tracts of the brain and cord. It certainly must be doubtful whether, in so short a time as is stated, that is, after recovery from the first violent reaction caused by its removal, the nerve-centres and their connecting tracts can have regained their normal and healthy condition. The patient has been months, possibly two or three years, in developing, by indulgence in opiates, a condition of the nervous system that is genuinely pathological. It is extremely questionable whether this profoundly neuropathic condition can be entirely cured in so short a time, and whether, after the first serious explosion has passed, the morbid appetite will not still exist, or if not the appetite in its most intense form, a general condition which is as distinctly pathological as when the patient was taking large doses. Obersteiner says: "Not infrequently the patient will be most benefited by a diminution of his quantity, while a complete withdrawal will only produce other disorders;" such disorders are apathy, despondency, mental indecision, in short, just such as lead to the early resumption of the drug in many cases, and which point most assuredly to an unrelieved pathological state of the general nervous system.

A third objection to the sudden withdrawal, as advocated by Levinstein, is the uncertainty of the truth of his assertion that the human organism tolerates better a violent and sudden treatment. Certainly active surgical interference is remarkably well borne by the human system, but the condition of a person requiring surgical measures is very different from that pathological state of the nervous system seen in cases of the opium habit, and which has developed slowly and insidiously. The cases calling for surgery and for the sudden withdrawal of morphine are not analogous. The sudden withdrawal does not, according to all generally understood physiological rules, remove or clear up the pathologically existing state of the nervous system developed by the opium habit. Time alone, combined with the appropriate tonic treatment and the gradual accommodation of the nervous system to the absence of the drug, can effect this.

The last argument in favor of sudden withdrawal, viz., that when the drug is gradually reduced the patients indulge in deceit and intrigue because out of patience with the treatment, is very questionable. It is more probable that the deception and intrigue are due to a certain demoralization which is the effect of the opium habit on the nerve-centres. And were the patients, who are supposed to be cured by the sudden withdrawal of the morphine, still detained in the hospital, it is more than probable that a majority of them would still practise deception in order to gratify their longings.

The method of gradual reduction is that which is most generally approved by physicians in this country. It is unquestionably more humane and more rational than the plan of sudden withdrawal. The first question that arises is whether the patient shall be treated at home or in an institution. Institution treatment is preferable, for then the patient is under daily observation of the physician and nurses, and the drug can be strictly withheld. Unfortunately, as has been already intimated, special institutions and special legislation are real desiderata in the judicious treatment of morphinists and inebriates. Whether treated at home or in a hospital, a hearty co-operation of the patient is much to be desired. For this reason recent cases who have been swept into this condition almost before they have been aware of it, and who earnestly desire recovery, are more hopeful than those older cases who have undergone a certain amount of moral degeneration, and, on account of weakened will-power, cannot give the physician their intelligent and earnest support.

The reduction of the dose is a matter of some importance, but must vary much with the individual case. Personal idiosyncrasy plays such a prominent part—one patient tolerating increase or reduction so much better

than another—that no definite scale of reduction can be laid down and strictly adhered to. The physician must feel his way carefully, and reduce the daily amount rapidly or slowly according to the effects witnessed upon the patient. In a general way, we can reduce the daily amount quite rapidly in the beginning, especially where large amounts have been taken. Thus I have reduced a patient who had been taking twenty-seven grains of morphine per diem to nine grains per diem in the course of three days. After this point the further reduction was more slow, and when five grains per diem was reached I was obliged to reduce the daily amount a sixth of a grain every three days.

Great patience is necessary on the part of the physician. It is always advisable to induce the patient, as soon as possible, to give up the syringe, and to administer the drug by the stomach. It is also advisable for the physician to reduce the dose without the patient's knowledge of the exact amount of reduction. Whenever the physician detects a too marked nervousness, and symptoms of severe neuralgia and the customary gastro-intestinal disturbance attendant upon a too rapid reduction, he must stop further reduction and allow the patient to become accustomed to the lessened amount which he is taking. By a gradual reverse accommodation to lesser and lesser amounts, the individual is brought back by slow degrees to his normal state. Oftentimes many months may be necessary to accomplish the result; sometimes even a year will elapse before the last fraction of a grain can be abolished.

During treatment a judicious administration of tonics should be kept up, such as iron, quinine, and strychnine. The patients are nearly always debilitated, and a nutritious diet and tonic medicinal treatment should be called upon to build up the weakened nerve-centres and restore the blood-corpuscles, which are always impoverished in cases of the opium habit. Milk, eggs, and rich broths, when borne well, should be freely allowed. The bowels should be attended to, for on their regularity largely depends the health of the patient.

Stimulants should be prescribed cautiously. Sometimes light wines with meals are of real benefit; but it would be a very grave mistake to in any way substitute alcohol for opium. In order to accomplish this the patient would necessarily be compelled to take larger quantities of the former, and the result would soon be that his nervous system would be in a more helpless state than ever, and that either opium or alcohol would be still required in even larger doses than before. It should be constantly borne in mind that opium and alcohol are both stimulants, and that one cannot be substituted for the other to the extent of producing any marked effect on the nervous system without severely aggravating the condition we are seeking to relieve.

Should there be a tendency to gastric irritability, combinations of dilute muriatic acid and gentian, or soda and nux vomica are serviceable.

Galvanism may be of great value, especially in the last stages of treatment, when neuralgia is likely to make itself felt again. The constant current exerts a more potent influence over neuralgia than the interrupted current. The difficulty of procuring a light, small, and cheap galvanic battery is probably the reason of its much less frequent use. Nearly all authorities agree, however, in ascribing to it great efficacy in the relief of pain. In its use the sittings should last from five to fifteen minutes. Generally from two to four cells are sufficient to relieve pain. Care, however, must be taken not to increase the force of the current beyond what the patient can comfortably endure. Moderate tingling or reddening of the skin under the negative pole and absence of pain are proper rules for guidance in its use. Authorities differ somewhat as to the point of applying the pole, some thinking that the positive pole should be applied to the point of exit of the nerve and the negative pole over the painful part, and others *vice versa*. Good results are unquestionably attained from either mode of application. It should always be borne in mind that a weaker current is to be used about the head and face, as the nearer to the brain is the application the more marked are the effects. Symptoms of distress and faintness are to be avoided while employing galvanism in this region.

Bartholow, in his work on hypodermatic medication, recommends the administration of atropia in conjunction with the morphia while the latter is being reduced. As the daily amount of morphia is diminished, the atropia is increased. He considers that by this method the terrible sufferings often encountered in the abolition of the final doses are frequently lessened.

During the latter part of the treatment it is well for the patient to be occupied with some light mental or physical work. The moral diversion attained thereby is often of great service in helping to direct the attention from self.

Prophylaxis.—In a discussion of the opium habit a word in regard to its prevention is pertinent. It is certain that much misery might be prevented could we only limit the indulgence in opium to its legitimate sphere—that of medicine. There seem to be only two ways in which this much desired result can be attained: First, by a more rigid legislation tending to restrict its sale for other than strictly medicinal purposes; and secondly, by a more careful and judicious use of the drug on the part of physicians. Thus far legislation has been a failure. Little or nothing has been accomplished in this direction, as we have seen, by the various attempts made by the Chinese Governments, notwithstanding that the law was in some instances most severe and was rigidly enforced.

In this country, whatever laws we have are practically a dead letter, for whoever wishes opium can easily buy it. In fact, it is very doubtful whether legislation can effect any moral reformation whatsoever when the sentiment of the community is not in sympathy with the reform in question.

Legislation being, and to all appearances likely to be for many years yet, a failure in the way of prevention of the opium habit, we must look to the physician as one who can in large measure in this country control the injudicious use of opium and its alkaloids—and especially the use of the hypodermic syringe and morphine. The physician can accomplish this result by never dispensing the drug, except as a medicine, and by never using it then, except when other means fail; by never trusting the drug or the syringe in the hands of the patient, but always administering it himself. *Charles P. Bancroft.*

OPIUM, POISONING BY. The poisonous nature of opium, and of the poppy, was known to the ancients at least as early as the time of Nicander (185–135 B.C.). Theophrastus (350–300 B.C.) does not refer to opium, nor to a product obtained from the poppy by incision, although he describes other juices obtained from plants by that method, and details the therapeutic uses of the poppy. Nicander, however, gives a clear description of the symptoms caused by a poisonous dose of a "drink prepared from the tears which exude from poppy-heads." Dioscorides, three centuries later, remarks of the poppy that, "if it be taken in larger quantity, it is capable of causing death." He also describes the method by which opium was then obtained; a method which did not sensibly differ from that which is practised at present. Pliny (A.D. 70) speaks of the toxic powers of opium, and cites the instance of Post. Licinius Cæcina, who, disgusted with life by protracted illness, terminated his existence by opium—an instance which does not seem to have been singular, as the narrative concludes with "item plerosque alios."

In modern times (since 1600) we can find mention of but 2 cases of homicidal poisoning by opium or its preparations or derivatives: One was that of Castaing, convicted in 1823, on "moral" evidence, for murder by morphine (Tardieu, p. 910); the second, the poisoning of a woman eighty-two years of age, in Germany, in 1883 ("Jahrb. f. Pharm. u. Tox.," 1883–84, p. 1139). In Tardieu's tabulation of 617 cases of "criminal poisoning," during twelve years, there occur 6 by opium; but as no further particulars are given, they were probably not

homicidal. Lesser, among his 131 cases of poisoning, which were the subject of medico-legal investigation includes 12 by opium and morphine, but does not state that any of them were homicidal. In the "Reports of the Register-General of Great Britain," it is stated that there were 5 murders by laudanum in the years 1863–64, of which we fail to find further mention in any work on toxicology.

On the other hand, instances of suicidal and "accidental" poisoning by the opiates are of very frequent occurrence. Of 1,409 cases of poisoning in England and Wales (1863–67), in which the nature of the poison is known, 632, or nearly forty-five per cent., were caused by opium or its derivatives. In the city of New York, in the years 1867–69, of 95 suicides by poison, 35 (thirty-seven per cent.) were by opium, etc.; and in the years 1870–75, of 392 cases of suicidal and accidental poisoning, 114 (thirty per cent.) were by opium and its preparations. Blyth estimates that forty per cent. of the suicidal poisonings in England are by opium and its preparations.

Among the "accidental" cases are classed many which, if not technically infanticidal, are such in everything except in the intent to make away with the particular infant who may be the victim. Fodéré, § 845, cites the case of a worthy precursor of Mrs. Winslow, who used an infusion of poppies in place of water in making the pap which she fed infants farmed to her, and who met her deserts by the guillotine in the latter part of the eighteenth century. To-day the Patent Office extends its protection to the dissemination of opiates, for which children are alleged to cry, and which are not only ready-made to the hand of the infanticide, but are also the cause of many truly accidental poisonings in the hands of ignorant mothers or careless nurse-maids.

Symptoms.—The symptoms produced by opium and its preparations, and by morphine—acute meconism—are practically the same whatever preparation of opium or salt of morphine may have been used. Other things being equal, however, morphine and its salts are more rapid in their action than opium or the preparations made from the crude drug.

The *time* at which symptoms manifest themselves is usually from half an hour to one hour after the poison has been taken. Frequently this period is much shortened. In children who have received large doses the poison sometimes begins to produce its effects within a very few moments or almost immediately. When the poison has been introduced by hypodermic injection, it acts more rapidly than when taken by the stomach; and when injected into the blood-vessels, almost instantaneously. Opium in solution acts more promptly than the same substance in the solid form, and the salts of morphine are more rapid in action than the alkaloid itself. Opiates administered by the rectum are more rapid in their action than when given by the stomach. The symptoms appear earlier when the poison is taken while fasting than when it is taken upon a full stomach. In exceptional cases the interval between the taking of the poison and the appearance of its effects is very much shortened even in adults. Thus, ʒ jss. of liquor opii sedativus has caused total insensibility in fifteen minutes, and death in an hour and twenty minutes. Cases have also occurred in which the action of the poison has been much retarded, although taken in solution. Thus instances are recorded in which no symptoms were produced in nine, twelve, fourteen, and eighteen hours by ʒ jss., ʒ ss., ʒ ij., and ʒ jss. of laudanum.

The clinical history of acute morphine- or opium-poisoning may be divided into three stages.

The first period, that of increased nervous excitability, is usually of short duration in the acute form of poisoning, although cases are recorded in which it has lasted fourteen and eighteen hours. It is frequently entirely absent, when large doses have been taken. This stage is marked by restlessness, great physical activity, loquacity, greatly increased imaginative power, frequently to the extent of hallucination, always of a pleasing character, and by increased cardiac action. In adult males priapism sometimes occurs during this stage. Vomiting is also of occasional occurrence, and greatly improves the patient's chances of ultimate recovery.

The condition of excitation passes, sometimes rather suddenly, into an intermediate stage of diminished excitability. The patient becomes weary, incapable of physical exertion, dull, and drowsy. He complains of a sense of weight in the extremities and an irresistible desire for sleep, to which he finally yields if not kept awake. The sleep is at first seemingly normal, though profound. The pulse and respiration are normal. The patient may be roused and sometimes kept awake by shaking him, by the infliction of pain, or by loud talking. The face is pale, the lips are somewhat livid, the surface is covered with perspiration, and the pupils are contracted. During this period the patient frequently experiences a violent itching of the skin, which is sometimes followed by the appearance of an exanthem which may be papular, red, bluish, or almost colorless, or resembling those of urticaria or of scarlatina.

The condition of somnolence is of short duration, and passes quickly into the stage of narcosis. The patient can no longer be roused, even by the most violent means. He lies motionless and senseless, with eyelids closed or partly closed. The surface is bathed in profuse perspiration, which exhales the odor of opium in opium-cases. The face is pale, the lips are blue, the lower jaw is dropped, and the muscles are completely relaxed. The pupils are insensible to light, and contracted to the size of pin-heads. A few cases are, however, recorded in which the pupils were said to be dilated. At first the superficial arteries, temporals and carotids, are seen to pulsate fully, strongly, and rapidly, while the respiration is slow and shallow (eighty pulsations in the minute to four respiratory movements have been observed). Later the pulse becomes feeble, slow, irregular, and easily compressible. The respiration becomes slow, shallow, stertorous, and accompanied by mucous râles. Retention of urine occurs early in the history, and continues until death or recovery.

From this period, if the case do not yield to treatment the poisoning usually proceeds rapidly to a fatal termination. The surface of the body and even the expired air become cold. The skin is cyanosed and covered with a cold clammy perspiration. The pulse becomes slower, more feeble, and gradually imperceptible. The respiration is more shallow and feeble, while the râles become more pronounced. Individual muscles, or groups of muscles, are agitated by short, clonic twitchings, and occasionally convulsions and tetanus occur. Later the muscles become completely paralyzed, the respiratory movements are made at longer intervals and finally cease; the circulation continues after the cessation of respiration. Finally, the action of the heart is arrested and the patient dies quietly. Sometimes epistaxis and other hæmorrhages occur toward the end; and in some instances death results from cerebral hæmorrhage.

Should recovery follow after the stage of narcosis, the respiration gradually becomes more frequent and more natural, the pulse becomes first perceptible and then gradually passes toward the normal, while the condition of coma passes into one of deep sleep, which may continue twenty-four to thirty-six hours longer, although the patient can be roused.

In the great majority of cases in which recovery has progressed so far that the patient may be roused it will be complete. Nevertheless, occasional instances are recorded in which the victim has relapsed into a deeply comatose condition and finally died.

In cases of recovery the patient, on awakening, is weary, giddy, and uncertain in his movements. He may also suffer for some hours from nausea and headache, and for a longer time from loss of appetite and derangement of digestion. In two cases Dr. Edes (*British Medical and Surgical Journal*, 1881, cv., 251) has observed the presence of casts in the urine; in one case, accompanied by albumen.

Duration.—In cases of fatal poisoning by the opiates death usually follows in from twelve to eighteen hours

after the poison has been taken. Of 48 fatal cases, death followed within twenty-four hours in 43; within eighteen hours in 39; within twelve hours in 26; and within nine hours in 20. The minimum duration of the poisoning was forty-five minutes; and the maximum, fifty-six hours.

Cases are recorded in which the symptoms of narcotism have disappeared and the patient has died at a greater interval of time than the above maximum. In such cases, although the death may have been accelerated by the action of the poison, the fatal result is immediately due to other causes. Thus, in a case quoted by Taylor, a patient suffering from disease of the heart took, in four hours, two hundred drops of laudanum, and was bled to the extent of thirty ounces. On the sixth day he was sufficiently recovered to undertake a journey, and died on the eleventh day. In this case the cause of death was failure of cardiac action, aggravated at least as much by loss of blood as by opium.

In cases of death where the patient has suffered from a disease whose symptoms resemble those of opium-poisoning, and has also received a large dose of an opiate, the question of duration may become one of considerable medico-legal importance. In a case which came under the author's observation a physician had given a child of four months gtt. x. tinct. opii deodorata by mistake for tinct. opii camphorata. The patient suffered from well-marked symptoms of opium-poisoning, but under immediate treatment improved, and in forty-eight hours had apparently recovered. Death followed, however, in ninety hours, from acute hydrocephalus.

Obviously, the same causes which influence the rapidity of action of the poison, and those which modify the effects of unusually large or small doses, will also influence the duration of the case, whether it terminate in death or recovery.

Lethal Dose.—As the action of the opiates is much modified by conditions, such as age, habit, state of health, form of administration, and idiosyncrasy, it is impossible to fix a lethal dose applicable to all conditions. It may be said, however, that 0.065 Gm. or 1 grain, of morphine, or 0.4 Gm. or 6 grains, of opium, would cause symptoms of poisoning in an adult not habituated to the drug, and possibly would cause death.

The smallest amount of morphine of which we can find record as having caused death in an adult is 0.035 Gm. ($\frac{1}{2}$ grain) of the acetate in a patient who had previously had violent convulsions (*North Carolina Medical Journal*, 1879, iii., 228). Numerous instances of death from 0.065 Gm. (1 grain) of a salt of morphia are upon record.

As the proportion of morphine and other alkaloids in opium is subject to considerable variation (morphine, 2.7 to 22.8 per cent., average 10 to 14 per cent.; codeine, 0.2 to 8 per cent.; thebaine, 0.2 to 0.5 per cent.; narcotine, 2 to 10 per cent.; narceine, 0.1 to 0.4 per cent.; papaverine, 0.5 to 1 per cent.), the toxic power of one sample of the crude drug, or the tincture or other preparation made from it, may be much greater than that of another.

Of the cases of death from small doses of opium known to us, that in which the amount was the smallest is reported by Dr. Sharkey (*Medical Gazette*, xxxvii., 235), of a man who died after taking two and a half grains of the extract (equivalent to 0.25 Gm. or 4 grains, of opium). In a case cited by Wormley, a girl of seventeen years took two drachms of laudanum (equivalent to 0.58 Gm. or 9 grains, of opium), was seized with stupor in three hours, suffered the usual symptoms of narcotic poisoning, and died in about seven hours. Taylor cites a case in which a lady died from a dose of two drachms of laudanum, mixed, it was supposed, with chloroform; and another case, in which a woman died from half an ounce of laudanum (equivalent to 1.16 Gm. or 18 grains, of opium).

On the other hand, numerous cases are on record of persons, not addicted to the opium-habit, who have recovered from very large doses. Taylor mentions an instance in which five ounces of laudanum (equivalent to 12 Gm. of opium) were taken, even without producing sleep, and the patient recovered. The same author refers to two cases in which eight ounces of laudanum (equivalent to nearly 20 Gm. of opium) were taken, yet the patients recovered under treatment, although not resorted to for several hours. A still more remarkable case is referred to by Wormley, in which a pregnant woman took between seven and eight ounces (220 to 250 grams) of solid opium, yet recovered under treatment, after suffering from well-marked symptoms of narcotism. Although the relative immunity in these cases of very large doses may be ascribed in some degree to an idiosyncrasy of the patient, their escape has been probably more largely due either to non-absorption of the poison or to rejection of the major portion by vomiting.

Infants and children are peculiarly susceptible to the poisonous action of opiates, even in very minute doses. Cases of death from small doses of laudanum are cited as follows: Gtt. iv. (equivalent to $\frac{1}{6}$ grain, 0.011 Gm. of opium) in a child of nine months; the same quantity in a child of five weeks; gtt. v. (= $\frac{1}{5}$ grain, 0.013 Gm.) per rectum in a child of eighteen months; gtt. viij., during eighteen hours, in four doses (= $\frac{1}{3}$ grain, 0.022 Gm.), in a child of six weeks; gtt. iij. (= $\frac{1}{8}$ grain, 0.008 Gm.) in an infant of two weeks; ♏jss. (= $\frac{1}{10}$ grain, 0.0065 Gm.) in an infant of three days; gtt. ij. (= $\frac{1}{12}$ grain, 0.0054 Gm.) in an infant of five days; the same quantity in another of four days; ♏j. (= $\frac{1}{14}$ grain, 0.005 Gm.) in an infant of seven days; and gtt. j. (= $\frac{1}{25}$ grain, 0.0026 Gm.) in an infant of six days. A dose of grs. iv. pulv. ipecac et opii (= $\frac{2}{3}$ grain, 0.026 Gm. of opium) has caused the death of a child of four and a half years. Huseman refers to a case (Edwards) in which the amount that caused the death of a four-weeks-old child was as low as 0.006 Gm. (= $\frac{1}{10}$ grain) of opium, taken in the form of the camphorated tincture.

Even during this early period of life occasional instances of recovery from relatively large doses are met with. A case is reported by Dr. Corbet, in the *Lancet*, August 29, 1857, p. 220, in which an infant of one day received ♏xxx. (= 2.3 grains, 0.15 Gm. of opium), yet recovered within ten hours. This case is of interest, as the age of the infant precludes the possibility of its having become accustomed to the drug, as was probably the case with a child of six months who recovered from a dose of a teaspoonful of laudanum (= 4.6 grains, 0.298 Gm. of opium) (Simmonds), although treatment was delayed for an hour; and with another of nine months who recovered from a dose of two teaspoonfuls (= 9.2 grains, 0.596 Gm.) of the same tincture.

The dosing of infants and young children with officinal or proprietary preparations of opium by mothers and nurses is widely practised. One of the results of the practice is the large percentage of deaths from opiates among young children. A tabulation of 144 cases of opium-poisoning, taken chiefly from English and American journals, gives this result:

	Total cases.	Children less than one year.	Children less than five years.	Children less than ten years.
Laudanum	79	24	25	26
Opium	18	9	10	11
Morphine	34	3	5	5
Patented opiates	13	10	12	12
Totals	144	46	52	54
Percentage of total.		32	36	37.5

From which it appears that about one-third of the poisonings by the opiates occur in children less than one year old.

The poisonous action of the opiates is very greatly diminished by habit, probably more than that of any other poison. The amounts taken by adult opium-eaters, laudanum-drinkers, and morphine-injectors are sometimes enormous. Cases in which the consumption reaches two Gm. (grs. xxx.) of opium, or one-half, one, or even two ounces of laudanum (= 0.5, 1, 2 Gm.), in

twenty four hours are of by no means uncommon occurrence. Such cases sink into insignificance when compared with that of De Quincy, whose daily draught of laudanum at one time reached nearly nine fluidounces (= about 20 Gm. of opium). Kruger-Hansen relates the case of a patient who consumed in one year over three hundred grams of opium, a daily average of over 0.8 Gm. (about grs. xiii). Zeviani cites the case of a woman who, in thirty-three years, had taken over one hundred kilograms of opium, equivalent to a daily average allowance of eight grams (= nearly 125 grains); and as the dose is gradually increased by opium-eaters, the daily consumption in this case must have been much greater in the later years. Headland and Myers refer to instances in which grs. xviii. (= 1.16 Gm.) of morphine were taken daily; and the author met with the case of a young man of twenty, of profligate habits, who had reached the same quantity, when he terminated his career with a large dose of cyanide of potassium.

It is not to be inferred from these large amounts that an opium-eater can take an unlimited quantity of the drug without experiencing its poisonous action. It is simply a question of quantity—a quantity necessarily varying in each case—and instances are of frequent occurrence in which the opium-habitué has experienced the symptoms of acute poisoning, and has even died from the effects of an overdose.

The tolerance of opiates acquired by habit is not confined to adults; it is also produced in quite young children. A remarkable case in point was published by Dr. J. L. Little (*American Journal of Obstetrics*, 1878, xi.). A male infant, suffering from acute inflammation of the knee-joint, followed by an abscess, began at three weeks of age with small doses of paregoric, gradually increased to a teaspoonful. Subsequently tinct. opii was substituted, and then Majendie's solution of morphine, in doses gradually increased, until, when nearly eight months of age, the child took in one day two fluidounces of Majendie's solution (equivalent to 2.07 Gm., 32 grains) of sulphate of morphine.

Treatment.—The treatment in cases of acute opium-poisoning should be directed, first, to removal of unabsorbed poison from the stomach; and, second, to prevention of death by coma and cessation of respiration, until the processes of elimination have removed that portion of the poison which has been absorbed.

In the earlier stages of the poisoning, emetics are of value—zinc-sulphate or ipecacuanha; or, if the patient be an obstinate suicide, apomorphia, hypodermatically. On no account should tartar emetic, or any antimonial, be used as an emetic in this or any other form of poisoning. If a stomach-pump be obtainable, it is to be preferred to the exhibition of an emetic in most cases; particularly in the later stages, when, the patient having lost the power of swallowing, a hypodermic injection of apomorphia usually fails to provoke emesis. The pump is to be preferred to an emetic, not only on account of its more certain and rapid action, but also because its use does not tend to increase the cerebral congestion as does the exhibition of the emetics. On the other hand, in some exceptional cases, in which opium in substance has been taken, an emetic may be necessary to remove masses too large to enter the pipe. In cases likely to lead to litigation, the material removed by the pump should be preserved. The stomach having been emptied of its contents by the pump, the viscus is next to be well washed out, either with water holding finely powdered charcoal in suspension, or with an infusion of tea or a decoction of coffee, or water charged with some tannin, preferably tannic acid.

The administration of vegetable (or other) acids, other than tannic, before the poison has been removed from the stomach is distinctly contra-indicated, as favoring solution and consequent absorption. Afterward, however, the use of dilute, mild vegetable acids, in the form of lemonade, is of benefit, as they favor elimination, principally by the perspiration—to which end diaphoretics and diuretics are also indicated.

If the case be seen before the stage of sopor has been established, it should be prevented, if possible, by keeping the patient in motion—walking him between two sufficiently robust assistants, preferably in the open air, if location and weather permit, but not in the direct sunlight. This "ambulatory treatment" has been beneficially prolonged in some cases for from six to eighteen hours. Under its influence sometimes the action of an emetic which has remained inert is brought about.

If the patient be already in a lethargic condition, he is to be roused without delay. This is best accomplished by cold affusions to the head and spine, flagellation to the palms and soles, or to the back with damp towels, or the use of the faradic current. When roused, the patient is to be kept awake as above.

Should the respiration have ceased or become very slow, it may frequently be stimulated by the application of the induced current, the positive pole being applied to the root of the neck over the point where the phrenic nerve crosses the scalenus anticus muscle, while the negative pole is carried laterally over the anterior attachments of the diaphragm. If the galvanic current be not obtainable, or if it fail, artificial respiration is to be performed. To be of service this must be persisted in, in some cases, for many hours, and until normal respiration is again established. Dr. W. F. Cheatham has published (*North Carolina Medical Journal*, 1886, 20) a case in which this was the sole method of treatment. The respiration had ceased and the pulse was barely perceptible. Artificial respiration was applied. In thirty-seven minutes the patient made an effort of respiration; in an hour and forty minutes the respiration was five per minute, though stertorous. In nine hours consciousness returned, and recovery followed.

If the case be at all prolonged, distention of the bladder and possibility of reabsorption are to be prevented by the use of the catheter. *If this be done in a case in which there is the faintest possibility of litigation, the urine so removed should be carefully preserved.*

Little can be said in favor of the different drugs that have been used as so-called physiological antidotes. Atropine, which is so frequently administered as an antidote to opium-poisoning, unquestionably dilates the pupils, but has little, if any, effect upon the respiration. Cases are recorded in which, although atropine has been given until the pupils were widely dilated, the respiration has ceased, and the patient has subsequently recovered by means of artificial respiration (see paper of Dr. Cheatham, quoted above).

Tinct. belladonnæ, strong infusion of coffee by the stomach or subcutaneously, extract of coffee, caffeine, brandy, digitalin, chloral hydrate, veratrum viride, and jaborandi have been used as antidotes. The last named or pilocarpine may be of value to increase the elimination, and thus lessen the duration of the poisoning.

Post-Mortem Appearances.—The autopsy reveals no lesions which are characteristic of opium-poisoning, except, possibly, the odor of the drug. Obviously, if morphine have been the substance taken, or if other more powerfully odorous substances be present, this will not be observed. The surface of the body is livid. Rigor mortis is said to be of shorter duration than usual, although an autopsy is reported by Tardieu at which rigor mortis was well marked sixty-two hours after death. Putrefaction is said to be more rapid than usual. The blood is fluid and dark. The vessels of the brain and meninges are gorged with blood, and the cut surfaces of the brain-substance present numerous dark-red spots. The veins of the scalp are also filled with blood. Serous effusions are frequently met with between the membranes, more rarely in the ventricles. The lungs are usually congested. The stomach and other viscera are normal, so far as the action of the poison is concerned. The bladder is generally full of urine.

The congestion of the cerebral vessels and of the lungs are the most noteworthy appearances. Yet, as they may be absent in opium-poisoning, and may be present where death has resulted from other causes, they are only of value as confirmatory evidence of the cause of death.

Analysis.—To detect the presence of morphine in the

viscera after death, or in articles of food, it is necessary to separate that alkaloid in a condition of as near purity as possible. In cases of opium-poisoning it is further necessary to search for meconic acid, and, if possible, for other of the opium-alkaloids.

If the facts of the case do not point very distinctly to opium or morphine as the poisonous agent, the process of Dragendorff should be followed for the separation of the alkaloids (Dragendorff, Ermittl. v. Giften, 2 Aufl., 1876).

If the indications of opium- or morphine-poisoning be sufficiently direct, the following simplified method for the separation of morphine and of meconic acid may be followed. The substances, if solid, are finely hashed and extracted several times with water containing one per cent. of hydrochloric acid at the ordinary temperature (if the materials be alkaline, the proportion of acid is to be increased to such an extent that the liquid, when in contact with it, retains its acid reaction). The aqueous extracts are filtered and shaken with amyl alcohol three or four times, and oftener if necessary, until the amylic alcohol is no longer colored, and the alcoholic layers separated. If the substances under examination be liquid, they are to be rendered acid with hydrochloric acid, filtered, and the filtrate treated with amyl alcohol. The amylic solution now contains meconic acid, if present in the objects examined; and the watery solution, the alkaloids as chlorides. To separate meconic acid, the amyl-alcohol solution is shaken with successive portions of water, which are separated, until the water is no longer colored. The alcohol is evaporated over the water-bath; the residue extracted with hot water; the solution filtered hot; the water evaporated over the water-bath; the residue extracted with alcohol; the solution filtered, and the alcohol evaporated. The tests for meconic acid are finally applied to a portion of the last residue. During this treatment a small portion of the meconic acid is converted into comenic acid, which does not, however, interfere with the tests.

To separate morphine from the aqueous liquid above mentioned, the hydrochloric acid is neutralized completely with ammonia, and the liquid rendered distinctly acid with acetic acid, and evaporated over the water-bath to the consistency of a syrup. The residue is extracted with four or five volumes of ninety-per-cent. alcohol and filtered. The filtrate is freed from alcohol by distillation. The residue, diluted with a small quantity of water, if thick, is heated to 50° to 60° C., an equal volume of amyl alcohol* is added, and then sufficient ammonium-hydrate solution to render the solution distinctly alkaline. The mixture is next strongly shaken for half an hour, the amylic alcohol separated, and the extraction of the aqueous liquid with amylic alcohol repeated three times. The united amylic solutions are evaporated to dryness; the residue extracted several times with warm (not hot) water slightly acidulated with sulphuric acid, and the solution filtered. Upon the acid filtrate is floated a mixture of ten parts absolute ether and one part (ninety-five per cent.) alcohol; ammonium-hydrate solution is added to alkaline reaction, and the whole strongly agitated. The ether-alcohol layer is separated; the extraction of the, now alkaline, aqueous liquid is similarly repeated several times, and the ether-alcohol evaporated in a number of small watch-glasses. To portions of the residue so obtained, either dry or dissolved in a few drops of water, as the nature of the test may require, and now sufficiently freed from coloring and other foreign substances, the tests for morphine are to be applied.

Tests.—I. *Morphine.* 1. With the general reagents for the alkaloids, the morphine-salts give reactions as follows, the fractions indicating the maximum of dilution in which the alkaloid is capable of reacting: With *phosphomolybdic acid*, yellowish, amorphous precipitate, $\frac{1}{5000}$; with *iodine in potassium iodide solution*, red-brown, amorphous precipitate, $\frac{1}{5000}$; with *iodide of potassium and bismuth*, amorphous precipitate, subsequently changing to silky needles, $\frac{1}{5000}$; with *auric chloride*, lemon-yellow precipitate, becoming darker; with *phosphotungstic acid*, flocculent precipitate, $\frac{1}{10000}$; with *iodhydrargyrate of potassium*, yellowish, amorphous precipitate, $\frac{1}{10000}$; with *platinic chloride*, slowly, yellow, crystalline precipitate, $\frac{1}{100}$; with *picric acid*, bright-yellow, amorphous precipitate, $\frac{1}{100}$; and with *tannic acid*, a faint cloudiness, becoming somewhat thicker on standing. For the above tests the solutions of the alkaloidal residue are to be made with very dilute sulphuric acid, and the reagents should be as nearly neutral as their natures will permit.

2. Morphine dissolves in concentrated nitric acid with an orange-red color, which gradually changes to yellow. Addition of stannous-chloride solution does not change the color of the yellow solution to violet, as it does with the similar color obtained with brucine. Limit, 0.01 milligram.

3. Morphine dissolves in concentrated sulphuric acid, forming a colorless solution. If this solution be heated over the water-bath for an hour, and allowed to cool or, preferably, if it be allowed to stand in a desiccator twenty-four hours, and then treated with a trace of nitric acid or a minute granule of saltpetre, a beautiful violet color is produced, which soon changes to purple-red, and then gradually fades. Limit, 0.001 milligram (A. Husemann).

A further portion of the sulphuric-acid solution, if treated, after warming and subsequent cooling as above, with a small fragment of potassium dichromate, assumes a mahogany-brown color (J. Otto).

4. A fragment of solid morphine moistened with a solution of ferric chloride, as neutral as possible (best obtained by dissolving the chloride obtained by the dry method in water), assumes a brilliant blue color.

For the success of this test it is essential that the morphine-salt be as free from impurities as possible, that little or no free acid be present, and that but a small quantity of the reagent be used. The color gradually changes to green and brown (Robiquet). Limit, 0.1 milligram.

5. A fragment of morphine moistened with Fröhde's reagent (a freshly prepared and colorless solution of 5 milligrams molybdate of sodium or ammonium, in 1 c.c. sulphuric acid) colors the reagent violet in a short time. The color changes to blue, and then to dirty green, and, finally, to faint reddish. Addition of water discharges the color instantly. Limit, 0.005 milligram.

6. If a mixture of 1 part morphine and 4 parts cane-sugar be added to concentrated sulphuric acid, the acid is colored dark red (Schneider, Weppen). Limits: With 0.1 milligram, distinct rose-red; with 0.01, rose-red a few moments after addition of a drop of bromine-water.

A similar reaction is obtained with biliary salts, albumen, oleic acid, codeine, etc.

7. Dissolve a small quantity of iodic acid in a few drops of water, in a small test-tube, and agitate with a few drops of chloroform; the latter must remain colorless. Add the solution to be tested, and again agitate; the chloroform, which settles to the bottom, has a violet color, in the presence of morphine, while the aqueous layer is yellowish. Now float upon the surface of the liquid dilute ammonium hydrate, with as little mixing of the liquids as possible; a brown band is formed at the junction of the ammoniacal and aqueous liquids (Serullas, Duflos, Lefort). Limits: For the red color of the chloroform, $\frac{1}{7000}$; for the dark band with ammonium hydrate, $\frac{1}{10000}$.

8. Add a few drops of nitrate of silver solution to a solution of a morphine-salt (preferably acetate), a gray precipitate of metallic silver is formed, more rapidly on warming the mixture. Filter the solution from the precipitate, and add nitric acid to the filtrate, a red color is produced (Horsley). Limit, 0.3 milligram.

9. Moisten the solid residue with a few drops of concentrated sulphuric acid and heat over the steam-bath, add a minute fragment of ferrous sulphate, heat a few moments, and cautiously transfer the acid liquid to a glass capsule containing 2 or 3 c.c. concentrated ammonium-hydrate solution, in such a way that the acid

* It is absolutely essential that the amylic alcohol used should be purified, *shortly before use*, by repeated redistillation, until a portion, on evaporation, yields no residue capable of reducing iodic acid.

under runs the alkali; at the junction of the two a red color, passing to violet at the edges, is developed, and the ammoniacal liquid is colored pure blue. On mixing the two liquids the blue color alone remains (Jorissen). Limit, 0.006 milligram.

10. Dissolve the solid residue in a few drops of concentrated sulphuric acid; transfer to a test-tube, and heat in the oil bath to 190° to 200° C., until the mass has become green-black and opaque. After cooling somewhat, drop the contents of the test-tube slowly into another test-tube containing 10 c.c. water; the water assumes a blue color. Divide the solution into two parts. Shake one-half with ether and the other with chloroform. The ether layer assumes a purple color; the chloroform, a blue color (Jorissen). Limit, 0.4 milligram; with smaller quantities the chloroform is greenish.

11. Add to the solution five or six drops of a solution of ferric chloride (1 gram of crystallized Fe_2Cl_6 in 8 c.c. H_2O), and then three or four drops of a solution of ferricyanide of potassium (1 gram ferricyanide *free from ferrocyanide* in 120 c.c. H_2O). In the presence of morphine a fine blue color is produced (Kieffer, Kalbruner, Otto).

The reaction is prevented by the presence of a considerable excess of acid. The test-solutions should be freshly prepared, and direct sunlight is to be avoided. Limit, $\frac{1}{14000}$.

12. Dissolve the solid in warm, concentrated hydrochloric acid, add a drop or two of concentrated sulphuric acid, and evaporate on the oil-bath at 100° to 120° C. In the presence of morphine a purple color is produced, still visible in the presence of the accompanying carbonized matter. After evaporation of the hydrochloric acid, a further quantity of the same acid is added, and the mixture neutralized with sodium carbonate; a violet color is produced, which does not fade, and does not communicate any color to ether. On addition of a few drops of a concentrated solution of iodine in hydriodic acid, the color changes to green, and the pigmentary substance now dissolves in ether with a purple color (Pellagri).

The reaction is due to the formation of apomorphine, and is consequently also observed with codeine.

13. A fragment of morphine, moistened with a solution of selenate of sodium in sulphuric acid, gives a fine green color. A similar reaction is obtained with codeine (Lafon). Other reactions of morphine are:

14. A red color with chlorinated soda and ammonia (Fairthorne); unsatisfactory.

15. A green color with ammonio-sulphate-of-copper solution (Lindo, Nadler); unsatisfactory.

16. A brown color when treated with sulphuric acid and perchlorate of potassium (Siebold, Grove).

17. A dirty violet with sulphuric acid and arsenate of sodium (Tattersall).

18. Flesh-color, changing to violet and green, with sulphuric acid, sodium sulphide, and gentle heat (Vitali).

19. A red color, increasing in intensity, with a drop of methylenacetochlorhydrin (Grimaux).

Of the above reactions for morphine, those upon which the most reliance is to be placed are Robriquet's, No. 3, Jorissen's, Nos. 8 and 9, and Pellagri's, No. 11; and of these, the last two are more delicate than the first named. The other tests, while very delicate, are not as characteristic. The reduction-tests, 4, 6, 7, and 10, respond with reducing agents other than morphine, but not with other vegetable alkaloids. The chief reason for the preference given the tests mentioned is that no ptomaine is known to respond to them, while post-mortem alkaloids have been obtained capable of giving the reactions with the other tests (see Ptomaines).

II. *Narcotine.* The reactions of the alkaloids of opium other than morphine are at present of but little toxicological interest, as they are substances which are not commonly met with, and hence are unlikely to cause poisoning. For the purpose, however, of distinguishing between morphine- and opium-poisoning by analysis (a distinction which may be of great medico-legal importance), the reactions of narcotine and of meconic acid (see below) are taken advantage of. Narcotine is chosen from among the other opium alkaloids for this purpose, partly because it is more abundant in opium, and partly because of the sharpness of its reaction with sulphuric acid.

If the Dragendorff method have been followed, narcotine should be searched for in the residue of evaporation of benzol from the alkaline solution.

1. Of the general reagents for the alkaloids, phosphomolybdic acid, iodhydrargyrate of potassium, iodine in iodide of potassium, and picric acid give precipitates in solutions of $\frac{1}{1000}$ to $\frac{1}{5000}$.

2. Moistened with concentrated sulphuric acid at the ordinary temperature, narcotine produces an intensely yellow solution, which, on gradual heating, changes to orange, then, beginning at the borders, blue-violet, and, when the heat has been raised to the point of volatilizing of the acid, dark red. The colors are presented more slowly, but more purely, by dissolving the residue in dilute sulphuric acid and evaporating quite slowly (Couerbe, Husemann). Limits: $\frac{1}{2000}$, very evident; $\frac{1}{4000}$, faint carmine only.

3. Dissolve in concentrated sulphuric acid, let stand an hour, and add a trace of nitric acid; a red color, which for some time increases in intensity.

III. *Meconic Acid.* 1. Crystallizes in white, glistening prisms, either single and large, or small and arranged in bundles, which at 100° C. lose their water of crystallization and become opaque. If heat have been applied to the solution in the presence of acids, the shorter, prismatic crystals of comenic acid will be also observed.

2. Meconic acid, or a meconate in solution, gives white or yellowish precipitates with lead-acetate, nitrate of silver, mercurous nitrate, and mercuric nitrate.

3. The characteristic reaction of meconic acid is the formation of an intense red color when the acid or one of its salts is moistened with a solution of ferric chloride (Sertürner). The color does not disappear either on warming or on the addition of hydrochloric acid, or of auric chloride, or of mercuric chloride.

Comenic acid gives the same reaction. It can only be present as a product of decomposition of meconic acid. Acetic and sulphocyanic acids and their salts also give a red color with ferric chloride. The former may be present as a normal food-constituent, and the latter is present in the saliva in quantity sufficient to give the reaction without any preliminary purification. The red color, however, produced by acetic acid is discharged by heat or by the addition of hydrochloric acid, and that due to the sulphocyanate disappears instantly on addition of auric chloride or mercuric chloride solution.

Failure of Detection.—In the works upon toxicology are found recorded a number of cases in which an analysis has failed to reveal the presence of either morphine or meconic acid. The causes for such failures are mainly two—incomplete or imperfect methods of analysis, and removal of the poison by evacuation, absorption, and elimination. In the earlier cases failure may have also resulted from imperfect methods of isolating the alkaloid.

One of the most common causes of failure, due to incomplete analysis, is to be found in the false but widespread notion—prevalent, it would seem, even among those who should be better informed—that the material found in the stomach is the only portion of the body (if it may be so called) which it is necessary to examine.

Woodman and Tidy cite in comparison two cases, but fail to assign the true cause for the difference in the results of the analyses. In one case a man, aged twenty-eight, admitted having taken a dose of laudanum, was profoundly comatose, and an empty bottle which had contained laudanum was found at hand. "*Every means to restore him was tried*, but he died" in about twenty-four hours. "An analysis of the *contents of the stomach* for morphia and meconic acid was made, but not the slightest trace of either was discovered." The second case was that of the dead body of an escaped lunatic, found in an unfinished building four months later, in an advanced stage of putrefaction, and without any evidence of the cause of death other than an empty bottle labelled

"Laudanum." "The stomach was in a dried-up state, and seemed covered internally with a brownish-red matter. One-half being submitted to analysis, morphia was detected in considerable quantity, as well as a trace of meconic acid."

"Why in one case was its discovery so easy, and in the other impossible? There is but little doubt that the true explanation is to be found in the length of time that elapsed between death and the exhibition of the poison."

To this conclusion we in no wise agree—firstly, because there is no evidence of how long a time elapsed in the second case; and, secondly, because an explanation more simple, if less flattering to the analyst, is obvious. If "every means" of restoration mean anything, it means that in the first case, among other things, the stomach was thoroughly pumped and washed out, and the result of the analysis is simply evidence of the perfection with which this method of treatment was carried out. In the second case the deceased had died without medical interference, and, as vomiting is very rare in opium-poisoning, that portion of the dose which he took over and above the amount required to cause death remained in the stomach.

Further, it is unquestionable that absorption, particularly when morphine is taken in solution, is sometimes very rapid; and it is quite conceivable that a case might arise in which, although the poison had been taken by the mouth, the conditions which always obtain when the poison is administered hypodermatically or per rectum would exist—*i.e.*, the stomach would contain no trace of the poison, while there would be still sufficient in other parts of the body to cause death. For these reasons, and for the additional one that the finding of poison in the contents of the stomach *only* is not positive proof of its administration during life, an analysis which is limited to the contents of the stomach, whatever be the nature of the poison, is in most instances entirely valueless.

Although the poison may be thus completely removed from the stomach by absorption, and although the process of elimination by urine, bile, and perspiration is in active progress during the entire duration of the case, it is difficult to imagine that a poison like morphine, which produces little or no secondary effects, should remain in the economy in sufficient amount to cause death, and yet in insufficient amount to reveal its presence by a properly conducted analysis.

The analysis should be directed first to any urine found in the bladder. By reason of retention caused by the poison, the amount is usually considerable, unless the patient have been catheterized before death; and, as this is one of the main channels of elimination, the poison may be found here in considerable amount after it has been in great part removed from other portions of the body.

Several ounces of blood, and at least one-third of the liver, should also be submitted to analysis, as well as the stomach and intestines and their contents.

Although morphine is more subject to decomposition than strychnine, it still withstands the influence of putrefaction quite well. In the case cited above it was detected four months after death; and Stas gives an account of a case in which he detected morphine in all the organs of a body after thirteen months of burial.

In cases of long burial, caution is required that ptomaines be not mistaken for morphine, as occurred in an Italian case, in which Selmi showed that what a careless analyst had taken for morphine was in reality a ptomaine (Selmi, sulle Ptomaine, 1878). Such a mistake is impossible, if the tests described above are carefully applied. *R. A. Witthaus.*

OPOPANAX, Codex Med. A gum-resin supposed to be derived from *Opopanax Chironium,* an umbelliferous perennial, resembling a coarse parsnip, whose root and stem contain a considerable quantity of a milky juice which on drying resembles the drug under consideration. This plant is a native of Europe and the Orient. Opopanax comes only from Persia and Asiatic Turkey, and has not been positively identified as a product of this species. It consists of irregular, opaque lumps or fragments, of an orange or brown color, with lighter specks, and yields when ground a yellow powder. Odor peculiar, unpleasant; taste bitter. It forms an emulsion with water, and is only partially soluble in alcohol or ether. The principal components of Opopanax are; a *resin,* probably composite and resembling those of galbanum and ammoniac, *gum,* and a very little *essential oil.* Medicinally it is related to the drugs just mentioned and is entirely superfluous, and, in this country at least, is obsolete.

Allied Plants.—See Anise.

Allied Drugs.—See Assafœtida, Galbanum, Ammoniac, etc. *W. P. Bolles.*

OPTIC NERVE AND RETINA. Macroscopic Anatomy.—The *optic nerve* emerges from the substance of the brain in two portions, which come from the *corpus geniculatum mediale and laterale.* These two portions are united into one (the optic-nerve tract) just under the *corpus geniculatum laterale;* yet a shallow furrow is seen for some distance, which marks this merging of the two portions of the nerve into one. The nerve, after the union, appears flattened, but gradually it takes on a more rounded shape. It travels around the *crus cerebri* (being bent toward the median line) under the *substantia perforata anterior,* and toward the *tuber cinereum,* and just in front of the *infundibulum* it is united with the optic nerve coming from the other side of the brain, to form the *chiasma nervorum opticorum.* Before the *chiasma* is

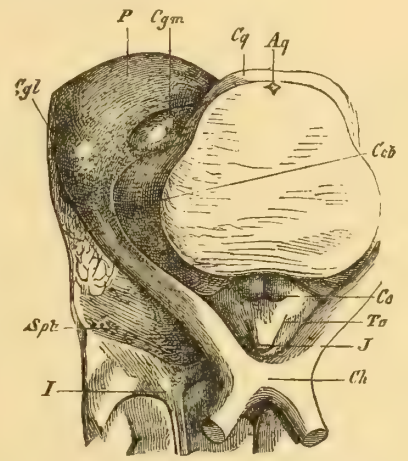


Fig. 2603.—Portion of the Base of the Brain from which the Optic Nerve emerges. The large hemispheres have been removed, so as to expose the posterior portion of the thalamus opticus. The crura cerebri are cut behind the corpora quadrigemina. *Cgm,* corpus geniculatum mediale; *Cgl,* corpus geniculatum laterale; *P,* pulvinar; *Ch,* chiasma nervorum opticorum; *Cq,* corpora quadrigemina; *Aq,* aquæductus; *Ccb,* crura cerebri; *Cc,* corpora candicantia; *Tc,* tuber cinereum; *J,* infundibulum; *I,* tractus olfactorius; *Spa,* substantia perforata anterior. (From Merkel.)

reached the optic nerve is not detached from the brain substance, but is adherent to it (see Fig. 2603).

From the two portions with which the optic nerve emerges from the brain, fibres have been traced backward into the *thalamus opticus,* and into the white substance of the occipital lobe (Gratiolet, Meynert), where, with all probability, the centre of vision is located.

In the *chiasma nervorum opticorum* a crossing of the nerve-fibres takes place, which, however, is a partial one only, from the fact that about the outer (lateral) third of each nerve remains uncrossed, while the other two-thirds are crossed. In this way two-thirds of the nerve-fibres of the optic nerve of the right eye have their centre in the left side of the brain, and *vice versa.* This is called the *partial decussation* of the nerve-fibres, and, from our present knowledge, this must be accepted as correct, in contradistinction to the *total* and *semi-decussation,* which are as yet maintained by some authors.

From the anterior surface of the *chiasma* the two separate optic nerves emerge as roundish bundles, flattened

from above and below, and diverging at once toward the two orbits. In its course toward this cavity each optic nerve runs in the *sulcus opticus ossis sphenoidei*. Just be-

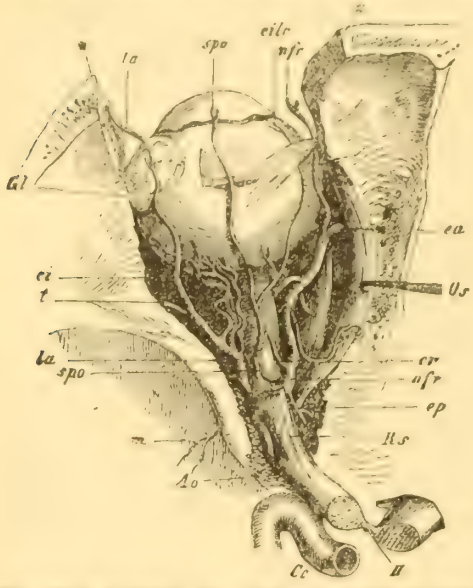


FIG. 2664.—Orbit, uncovered from above. *Cc*, carotis cerebralis; *Ao*, art. ophthalmica; *la*, art. lacrymalis; *spo*, art. supra-orbitalis; *nfr*, art. naso-frontalis. Branches of the art. lacrymalis: *m*, ramus meningeus; *t*, anastomosis with art. tempor. profunda; *ci*, art. ciliares. Branch of the art. supra-orbitalis: *cila*, art. ciliaris anterior. Branches of the art. naso-ciliaris: *ep*, art. ethmoidalis posterior; *ea*, art. ethmoidalis anterior; *cr*, art. centralis retinæ; *II*, nervi optici, anterior portion of chiasma. The left opticus is raised from its canal. From its sheath the rectus superior muscle (*Rs*) is seen to spring. *Os*, the superior oblique muscle is drawn aside by a hook. *Gl*, Lachrymal gland. (From Merkel.)

fore entering the *canalis opticus* it lies with its median half upon the *os petrosum*, while its lateral half lies upon the *arteria carotis cerebralis*. From the *chiasma* to the *canalis opticus* the nerve in the adult measures about ten millimetres, and is about five millimetres broad.

Having reached the *canalis opticus* the shape of the optic nerve is somewhat changed. It is more rounded, and, therefore, loses in breadth, the latter being reduced to about four millimetres.

Within the *canalis opticus* the optic nerve is firmly attached to the periosteum at its upper surface.

After the optic nerve has entered the orbit the direction of its course tends somewhat downward, and it makes a slight **S** shaped curve, with the convex side toward the temple, before it reaches the eyeball. It enters the latter a little downward and about three millimetres inward from the posterior pole, and about at a right angle to its axis. The length of the orbital portion of the nerve is from twenty-eight to twenty-nine millimetres (Merkel).

From the point where it emerges from the brain substance to its entrance into the eyeball, the optic nerve is surrounded by a sheath coming from the *pia mater* of the brain. When entering the orbit it receives a second (outer) sheath from the *dura mater*; this latter membrane at the *foramen opticum* is split into two portions, one of which forms the periosteum of the orbit, while the other forms the outer sheath of the optic nerve just mentioned.

The inner (*pia mater*) sheath forms the neurilemma of the nerve, and sends numerous bundles of connective tissue into the tissue of the optic nerve, which form the net-work of septa in which the optic nerve-fibres are held.

Pia and *dura mater* sheaths are, in the same way, held together by trabeculæ of connective tisue which run from the one to the other. The *arachnoid* sheath lies, in man, close upon the inner surface of the *dura-mater* sheath.

When the optic nerve has reached the eyeball its sheaths join the sclerotic. The nerve at this point becomes considerably thinner, and changes in color from white to gray. These changes are due to the fact that the nerve-fibres become non medullated.

After having entered the cavity of the eyeball through the sclerotic and choroid (*lamina cribrosa*) the nerve-fibres are bent almost at right angles and form the so-called *papilla optica*, from which they spread in a radiating direction toward all sides, and then form the nerve-fibre layer of the retina. From the manner in which the nerve-fibres change their course, it is plain that the optic papilla must have a more or less central depression (physiological excavation), which is surrounded by walls varying in thickness and height, according to the arrangement and number in which the nerve-fibres enter the retina at a given place.

The arrangement of the nerve-fibres in the retina is such, according to our present knowledge, that the nerve-fibres of the uncrossed bundle go to the lateral half of the retina, while those of the crossed portion go to the median half. Moreover, according to Liebreich, a greater number of fibres run upwards and downwards than to the sides. We further know that the fibres going to the *macula lutea* (the point of acute vision) come from the crossed as well as from the uncrossed bundles.

The way in which the nerve-fibres are distributed after having entered the eyeball (Michel, Liebreich, Vossius), is the following: The fibres which end between the *papilla optica* and the *macula lutea* pass over the lateral margin of the papilla in a direction straight outward. The fibres which leave the papilla optica at its superior and inferior margin run in arches beyond the macula lutea, and join each other there from above and below. The fibres which go to the median half of the retina leave the optic papilla from the beginning in a radiating direction.

It is furthermore known that the nerve-fibres which go

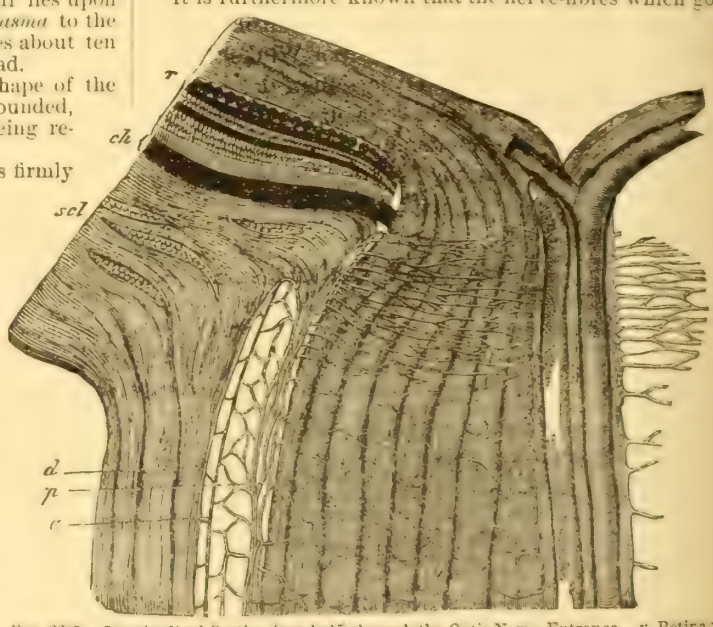


FIG. 2665.—Longitudinal Section (one half) through the Optic Nerve Entrance. *r*, Retina; *ch*, choroidea; *scl*, sclerotica; *d*, dura-mater sheath; *a*, arachnoid sheath; *p*, pia-mater sheath. Between *d* and *a* lies the subdural, between *a* and *p* the subarachnoidal (interstitial) space. The central retinal blood-vessels are seen surrounded by a small quantity of loose connective tissue. From Schwalbe.)

to the macula lutea lie in the outer lower quadrant of the optic nerve (at least near the eyeball).

The blood vessels of the intra-cranial portion of the optic nerve come from the blood-vessels of the brain and

from those of its pia-mater sheath. The intra-orbital portion receives its blood-vessels from the pia-mater sheath alone, until the optic nerve is entered by the central retinal blood-vessels, which is at a point from fifteen to twenty millimetres behind its entrance into the sclerotic.

The central retinal artery comes directly from the *arteria ophthalmica*, or from one of its branches. With the central retinal vein it enters the optic nerve at an acute angle from behind forward, and gradually reaches its more central portion (the central canal). In this latter position it enters the eyeball with the optic nerve, and is accompanied by the central retinal vein, the two being enclosed in connective tissue. After having entered the eyeball they branch off into the retina. As stated above, small branches of these central blood-vessels go to the tissue of the optic nerve as soon as they have entered it.

The intra-scleral portion of the optic nerve, as well as the optic papilla, receives blood-vessels from the central retinal blood-vessels and from the posterior ciliary blood-vessels. By the communication of the blood-vessels from these two sources the *circulus arteriosus nervi optici* (Zinn) is formed.

The spaces between the sheaths of the optic nerve communicate directly with the spaces found between the membranes of the brain, of which these sheaths are the direct continuations. Thus we have a subdural and a subarachnoidal space of the optic nerve-sheaths in direct communication with the spaces of the same name within the cranial cavity. They are lymphatic spaces, and are usually together spoken of as the intervaginal space of the optic nerve. At the entrance of the optic nerve into the retina this intervaginal space becomes, macroscopically at least, obliterated. After having reached the inner surface of the choroid the fibres of the optic nerve spread out in the manner above described, and form the inner portion of the retina, the light-perceiving organ of the eye.

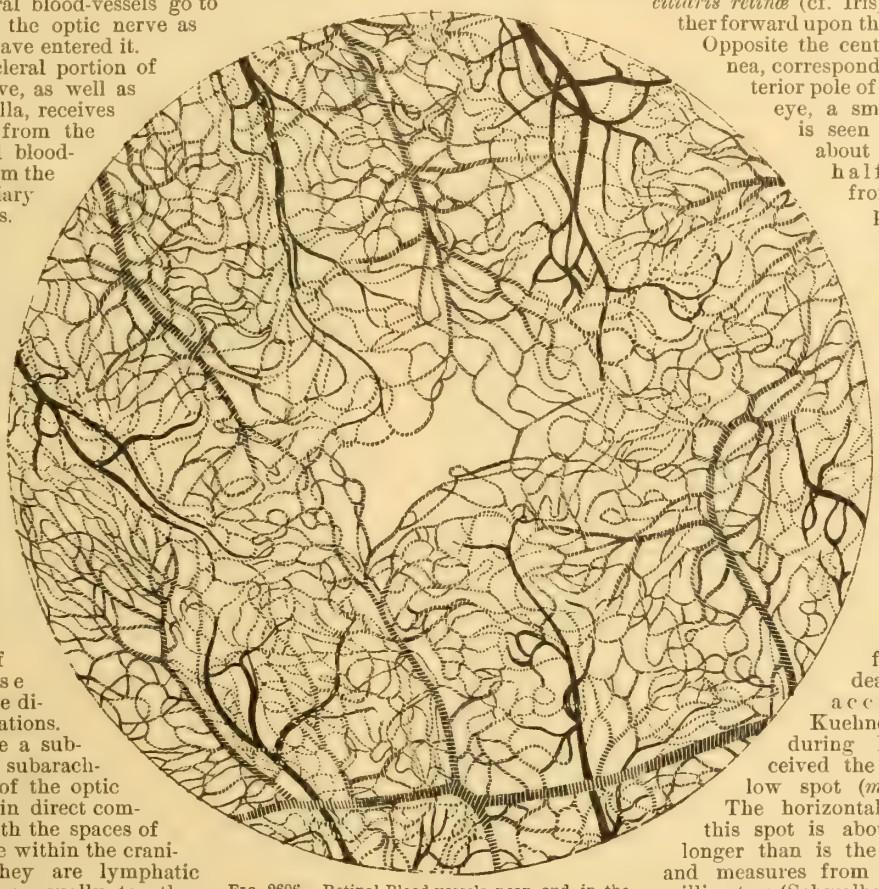


FIG. 2606.—Retinal Blood-vessels near and in the Macula Lutea. Arteries in cross-shading, veins solid. Copied from the drawing by Heinrich Mueller, and published by O. Becker. The part which appears totally free from blood-vessels is the fovea centralis.

The outer portion of the retina consists of a number of cellular layers and lies directly upon the choroid, only separated from it by the intervening layer of the pigmented epithelium cells, the *stratum pigmenti*, which was formerly considered to make a part of the choroid, but is now counted as a part of the retina.

The different layers of the retina are, according to the nomenclature at present adopted, the following ten, beginning with the inner surface of this membrane: 1, The internal limiting membrane (*membrana limitans interna*); 2, the layer of the optic nerve-fibres; 3, the layer of ganglionic cells; 4, the inner molecular layer; 5, the inner granular layer; 6, the outer molecular layer; 7, the outer granular layer; 8, the outer limiting membrane (*membrana (?) limitans externa;* 9, the rods and cones; and 10, the pigment-epithelium (*stratum pigmenti*).

The retina is thickest near the optic nerve entrance, and gradually tapers off toward its periphery, which lies at the beginning of the ciliary body (*pars non-plicata, orbiculus ciliaris*). This gradual diminution of its thickness is chiefly due to the fact that the nearer the periphery of the retina the more must the nerve-fibres be spread out. That it is, however, not the only cause, we shall see later on. The peripheral terminus of the retina (at least of its light-perceiving portions) is, from its shape, called the *ora serrata*, the nervous elements ending at the *orbiculus ciliaris* in a scalloped line. One part of the retina, the *pars ciliaris retinæ* (cf. Iris), reaches farther forward upon the ciliary body.

Opposite the centre of the cornea, corresponding to the posterior pole of the axis of the eye, a small depression is seen in the retina, about three and a half millimetres from the optic papilla and a little above it, which is called the *fovea centralis*. This latter forms a somewhat oval depression, with a diameter of from 0.2 to 0.4 mm., and of varying depth, and is surrounded by an oval portion of the retina, which, from a diffuse yellowish tint, which is found in the dead eye, but, according to Kuehne, exists also during life, has received the name of yellow spot (*macula lutea*). The horizontal diameter of this spot is about one-fourth longer than is the vertical one, and measures from two to three millimetres (Schwalbe). The *fovea centralis* does not lie exactly in the centre of the yellow spot, but it is somewhat nearer to the optic papilla. While the *fovea centralis* is the thinnest portion of the retina, the yellow spot is the thickest portion of the retina proper (except the parts close around the optic papilla).

In the living retina the outer surface has a slightly purple color (retinal purple, visual purple, rhodopsine, Kuehne, Boll) which disappears after death. This visual purple tints only the outer parts of the rods. It fades under the influence of light. Making use of this peculiarity, Kuehne has succeeded in obtaining "optograms" of windows and other bright objects on the retina of frogs by exposure. The visual purple is secreted by the pigment-epithelium, which, therefore, must be considered as of a glandular nature.

The average thickness of the retina is about 0.4 mm. at the margin of the optic papilla, and dwindles down to about 0.1 mm. at the *ora serrata*.

The blood-supply of the retina comes, in the main, from the central retinal artery. There are, furthermore, a

number of arterioles which enter the retina, coming from the arterial circle of the optic nerve and from the choroid near the optic nerve entrance. The venous blood leaves the retina by way of the central retinal vein.

The arteries in the retina are all "terminal" arteries. After having entered the optic papilla the central retinal artery splits into two large branches (sometimes it does so before entering the papilla), which again are divided each into two smaller branches. Thus we have two arteries going to the lower, and two going to the upper half of the retina, one of each of these goes in a temporal and one in a medial direction. The medial branches are smaller than the temporal ones. The temporal arteries form an arch around the macula lutea and send fine branches toward it. The fovea centralis alone is without blood-vessels (see Fig. 2606).

The veins in a general way follow the direction of the arteries. While the arteries are more or less straight in their course, the veins are somewhat tortuous.

The blood-vessels lie chiefly in the nerve-fibre layer of the retina, directly or near the membrana limitans interna. The smaller branches reach outward into the inner granular, and even into the outer molecular, layer. In the normal condition no blood-vessels are found in the outer granular layer, and in the layer of rods and cones. These outer layers receive most of their nutritive material from the capillary layer of the choroid (see Iris).

Minute Anatomy.—The dura-mater sheath of the optic nerve has an average thickness of 0.4 mm.; it is, however, considerably thicker near where it merges into the sclerotic (0.6 mm. and more). It consists of fibrillary connective tissue, interspersed with elastic fibrillæ. Between these fibres are found a number of flat, cellular elements, which are very thin, and have an oval nucleus, and which probably form endothelial membranes between the different layers of fibres (Schwalbe, Kuhnt, Key, and Retzius). The cells are more numerous in the eyes of the young than in those of the adult. The fibres run chiefly in a longitudinal direction, and especially so in the outer portion of this sheath; near its inner surface circular fibres prevail, but there are also fibres running in an oblique direction between the two. The inner surface of the dura-mater sheath is covered by a continuous layer of endothelial cells, which is easily demonstrated by the use of nitrate of silver. To its outer surface Tenon's fascia is attached by trabeculæ of connective tissue, covered with endothelial cells, which latter also form a membrane on the outer surface of the dura-mater sheath. The arachnoid sheath is, in the same manner, attached to the inner surface of the dural sheath by connective-tissue trabeculæ, which are covered with endothelial cells. The dura-mater sheath contains numerous blood-vessels and nerves. The latter follow, in a general way, the course of the blood-vessels, and have an enormously thick neurilemma (Henle).

The arachnoid sheath is throughout closely attached to the inner surface of the dura-mater sheath, and merges into it near the optic-nerve entrance. It forms a thin net-work of fine connective tissue and elastic fibrillæ, and is covered by endothelial cells on both surfaces. Near the sclerotic it merges into the dura-mater sheath. Thicker trabeculæ of connective tissue connect the arachnoid with the pia-mater sheath. Some of these come from the dura mater, and pierce the arachnoid to reach the pia mater. All of these trabeculæ are covered with endothelial cells.

The pia mater is only loosely connected with the chiasma by blood-vessels, but it closely surrounds the optic nerve, especially its orbital portion. It may be divided into two layers, an inner one of loose tissue, the fibres of which run chiefly in a longitudinal direction, and an outer denser one, in which, besides a circular arrangement of the fibres, such elements are found running in varying intermediate directions. It consists of connective tissue and elastic fibres, and cellular elements similar to those found in the dura mater. Its outer surface, as well as the trabeculæ running from it to the outer sheaths, is covered by a layer of endothelial cells. The pia-mater sheath is throughout very vascular. In the orbit it receives blood-vessels from the dura mater, and from recurring branches of the short ciliary arteries. Whether the pia-mater sheath also contains nerves, is as yet not known.

From the inner side of the pia mater innumerable fine trabeculæ spring forth, which form the net-work of con-

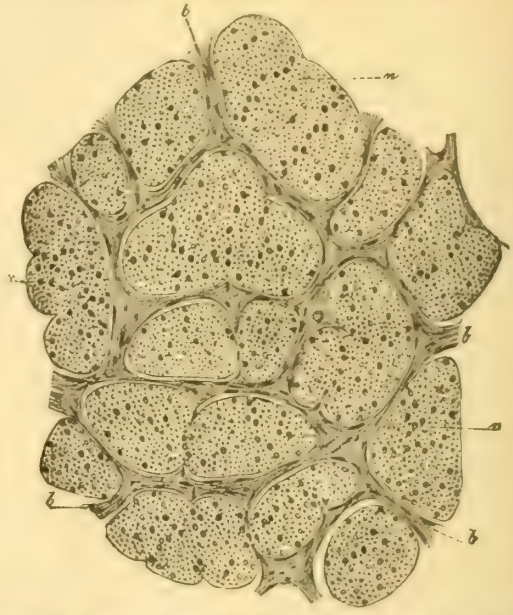


Fig. 2607.—Portion of a Transverse Section through the Human Optic Nerve. *b*, Connective-tissue trabeculæ coming from the pia-mater sheath; numerous spindle- and round-shaped nuclei are seen within them; also, transverse sections of blood-vessels; *n*, nerve fibres with their nuclei.

nective-tissue septa, by which the nerve-fibres are held together and in position. This net-work runs in a transverse and a longitudinal direction. The trabeculæ forming this net-work vary considerably in thickness, as do also the meshes formed by them (see Fig. 2607). They

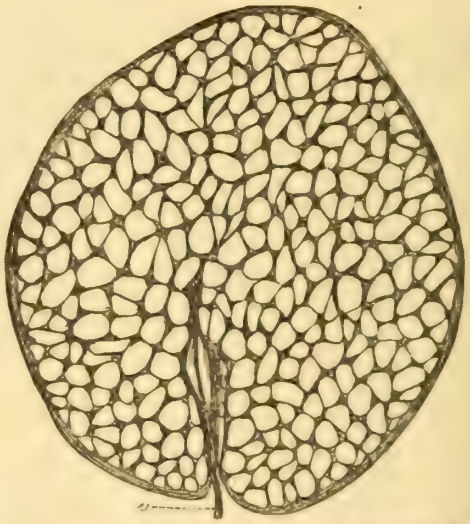


Fig. 2608.—Transverse Section of the Optic Nerve, close behind the Entrance of the Central Retinal Blood-vessels into It. *r*, Central retinal vein. (From Schwalbe).

consist chiefly of connective-tissue fibrillæ, but here and there elastic fibres are also found in them.

Where the central retinal blood-vessels enter the optic nerve, the pia mater enters with them, being, so to speak, pushed before and dragged along with these blood-vessels. Thus, what is called the central canal of the optic nerve

contains the central retinal blood-vessels, accompanied and held in position by tissue from the pia mater (see Figs. 2608 and 2609).

In this way small blood-vessels enter the centre of the optic nerve which originally belong to the pia mater, and these branches now feed, instead of the peripheral, the central parts of the optic nerve. Some of them may be traced forward to the neighborhood of the lamina cribrosa. Small branches from the central retinal artery are also seen to enter the nerve-substance.

Where the optic nerve enters the eyeball its sheaths merge into the sclerotic. The fibres of the dura-mater sheath, after having reached the sclerotic, are gradually bent in such a manner that they make a part of the outer layers of this membrane (one-fifth, Kuhnt) with whose fibres they intermingle. The arachnoid sheath becomes firmly united to the dura-mater sheath before this has reached the sclerotic.

The pia-mater sheath remains in close contact with the optic nerve a little longer than the dural sheath, when its fibres, too, are bent outward in such a manner as to enter

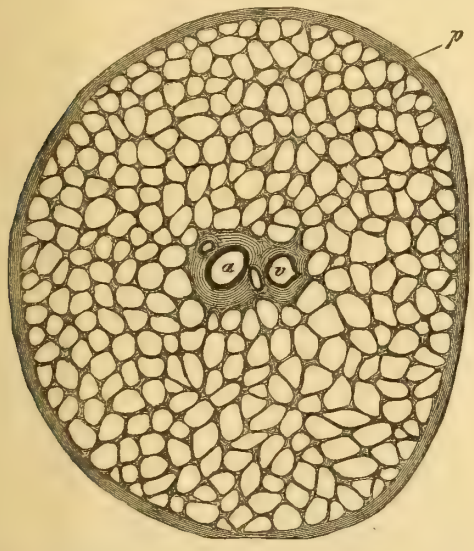


Fig. 2609.—Transverse Section through the Optic Nerve, nearer the Eyeball. *a*, Central retinal artery; *v*, central retinal vein; *p*, pia-mater sheath.

and make part of the sclerotic in its inner portions (one-fifth to two-fifths, Kuhnt).

The intervaginal space may be traced into the sclerotic to a varying depth. It may, in some eyes, even be found enlarged within this membrane; and in myopic eyes it is usually bent at about right angles, so as to split the sclerotic into two unequal parts for a varying distance.

The fibres of the optic nerve come in part from more distant portions of the brain, as mentioned above; in part they spring from the *corpora geniculata*, the *thalamus opticus*, and the *corpora quadrigemina anteriora* (Schwalbe). Where the *tractus opticus* lies upon the *substantia perforata anterior*, a thin lamella is seen to grow in between these two which contains numerous ganglionic cells, from which fibres are seen to enter the optic nerve-tract (Wagner). This lamella is called the *ganglion opticum basale* (Meynert). The tractus opticus consists of medullated fibres; the optic nerve-fibres within the corpora geniculata are, however, non-medullated.

The manner in which, according to most recent authors, the optic nerve-fibres are crossed within the chiasma has been detailed above. The theory of the partial decussation is the only one which will, in a satisfactory way, explain certain pathological phenomena. It should, however, be stated here again, that some authors stoutly maintain the theory of a total decussation, based on their own anatomical researches (foremost among these are Biesiadecki, Mandelstamm, and Michel).

It seems to be certain that the upper surface of the chiasma is covered by a thin layer of gray substance, which in many cases may be traced over the anterior angle down to the lower surface, while in other cases the latter receives a cover of gray substance from the tuber cinereum (Michel).

The nerve-fibres of the optic nerve are said to be thinnest in man. They form bundles, varying in thickness and shape, which lie in the meshes of the septa coming from the pia-mater sheath, being, however, separated from the connective tissue by a minute capillary lymph-space. The fibres run in a general way in a longitudinal direction, but sometimes they appear to anastomose with each other by being split dichotomously at very acute angles. This latter arrangement is more visible near the eyeball than farther backward.

The nerve-fibre bundles consist of fine and finest medullated fibres, and a peculiar cementing substance, neuroglia, and flat cells with oval nuclei. The nerve-fibres are medullated up to within the sclerotic canal. They differ very considerably in thickness and shape (see Fig. 2610).

According to Kuhnt these nerve-fibres have a fine sheath between the axis-cylinder and the medulla, while Tizzoni denies the existence of such a sheath. The axis-cylinders frequently show varicosities, which, however, are probably wanting during life. The medullary sheath of the optic nerve-fibres is very thin. A Schwann's sheath they have not, according to Kuhnt.

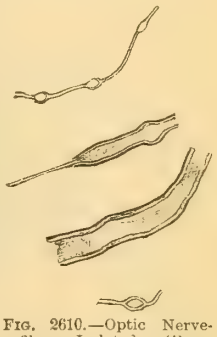


Fig. 2610.—Optic Nerve-fibres Isolated. (From Krause.)

The nerve-fibres are singly and collectively surrounded and bound together by the neuroglia, a soft, albuminous substance, which forms in hardened specimens a net-work whose direction is at right angles to that of the nerve-fibres (Leber). The oval nuclei which are found to lie upon the nerve-fibre bundles, and are arranged in rows, are inclosed in flat, cellular elements, with a number of offshoots which anastomose with each other. According to Krause the optic nerve consists of at least 400,000 larger and smaller nerve-fibres, and an unknown number of finest ones.

While passing through the sclerotica and choroidea the optic nerve undergoes several changes. Its diameter is gradually reduced to about 1.5 mm. This thinnest portion lies at the level of the choroid. In this portion the whitish color of the optic nerve also is changed into a translucent gray. Both these changes are due to the fact that the nerve-fibres here lose their medullary sheath. The manner in which this takes place has been fully detailed in the article on glaucoma (cf. Glaucoma), at least for the hypermetropic eye. It remains here only to state that, while the line of the transition from medullated to non-medullated nerve-fibres in the hypermetropic eye approaches nearest to the shape of a deep funnel, in the myopic eye this transition takes place almost in a straight plane, or so that in a longitudinal section it forms a convex line, with its convexity toward the vitreous body.

After the pia-mater sheath has joined the sclerotic this latter membrane surrounds the optic nerve. It does not, however, form one large opening for the admission of the optic nerve *in toto*, neither does the choroid. Both these membranes help in the formation of the septa of the nerve. This portion, from its sieve-like appearance, is called the *lamina cribrosa*. In the lamina cribrosa the connective-tissue trabeculæ, severing the nerve-fibre bundles in a transverse way, by the addition of scleral and choroidal fibres, become much thicker and more numerous, while the longitudinal ones become much shorter. In transverse sections it is apparent that the meshes between the septa are also considerably smaller than in the orbital portion of the optic nerve.

The septa contain here, as they do in the nerve further back, small blood-vessels, so that the meshes of the vas-

cular net-work are considerably smaller, and, consequently, the blood is in more direct contact with the nerve-fibres.

The intervaginal space (subdural and subarachnoidal spaces) of the optic nerve is a lymph-canal which, as stated, is in direct communication with the intra-cranial cavity and can be easily injected from it. It is, furthermore, in communication with lymph-channels which form a fine net-work within the optic nerve. There are, moreover, small lymph-fissures in the dura-mater sheath which communicate with the lymph-channels in the orbit. The net-work of fine lymph-canals in the tissue of the optic nerve is easily injected by inserting the syringe between the pia mater sheath and the optic nerve. It lies inclosed in the septa which separate the nerve-fibre bundles, and between the septa and the nerve-fibre bundles. The lymph-canals seem to be wider within the lamina cribrosa.

When the intervaginal space is injected, the fluid, after having filled this space, is seen to pass from the fundus of the intervaginal space obliquely through the sclerotic, and to enter the suprachoroidal space (lying between sclerotic and choroidea). There is also a lymph-channel in the axis of the optic nerve accompanying the central retinal blood-vessels, which leaves the nerve with these

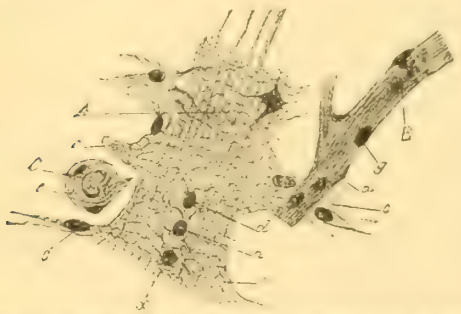


Fig. 2611.—Optic Nerve-fibre Bundle, from a Portion 7 mm. behind the Lamina Cribrosa. *A*, nerve-fibre bundle—around its fibres is seen the net-work of neuroglia, into which the flat cells send their offshoots; *c*, *d*, and *h* are such flat cells arranged in a row; *e*, neuroglia; *B*, connective tissue trabeculæ; *a* and *g*, oval nuclei; *C*, such a trabecule cut transversely.

blood-vessels, and goes with them through the orbit and into the intra-cranial cavity.

The lymph-stream goes from the intra-cranial cavity by way of the intervaginal space down to the eyeball and into the suprachoroidal space (Quincke, Deutschmann). The lymph-stream in the lymph-channel situated in the axis of the optic nerve is in the reverse direction, and goes through the orbital tissue into the cranial cavity. Within the optic nerve the stream, in the transverse channels, is said by Gifford to be in the direction toward the choroid and intervaginal space, in the longitudinal ones toward the brain, "at least for some millimetres back of the eyeball."

After the optic nerve has passed through the lamina cribrosa and has reached the inner surface of the choroid, its fibres, as stated, change their course and spread over the inner surface of the retina. The portion of the nerve which lies in front of the lamina cribrosa, and is surrounded by the elements of the outer layers of the retina, is called the optic papilla. The central depression resulting from the change in the course of the nerve-fibres is the physiological excavation. Within the latter the connective tissue of the central canal, with the central retinal vessels, reaches almost to the inner surface, but is separated from the vitreous body by a small meniscus of loose connective tissue (Kuhnt). The blood-vessels branch off here and pass also over into the retina.

The diameter of the optic papilla is, on an average, 1.6 mm. (Schwalbe).

Within the papilla the nerve-fibres are still arranged in larger and smaller bundles, and divided from each other and held in position by small connective-tissue septa, which come from the connective tissue in the central canal of the optic nerve.

The different layers of the retina (see Fig. 2612) may well be divided into two larger groups (Schwalbe) in the following manner:

I. Inner portion of secondary ocular vesicle:

1. Membrana limitans interna.	Brain layer.
2. Nerve-fibre layer.	
3. Ganglionic layer.	
4. Inner molecular layer.	
5. Inner granular layer.	
6. Outer molecular layer.	
7. Outer granular layer.	Neuro-epithelial layer.
8. Membrana limitans externa.	
9. Rods and cones.	

II. Outer portion of secondary ocular vesicle:

10. Pigment-epithelium layer.

Toward the periphery of the retina its layers become considerably thinner than they are near the optic papilla. This is especially the case with the optic nerve-fibre layer and the ganglionic layer, less so with the other layers, and least with the inner granular layer.

All the different elements constituting the retina are held together by a supporting tissue of the connective-tissue type, which, according to Mueller, who first described it, forms the so-called radiating or supporting fibres, known also, in honor of their discoverer, as *Mueller's fibres*. These fibres run through the tissue of the retina from its inner toward its outer surface, and are, therefore, at right angles to the general arrangement of the layers of this membrane. They are more numerous in the peripheral portions of the retina, and stand closer together than in the portions near the optic papilla, and are but little developed in the region of the macula lutea. They are flat, cylindrical bodies, with wing-like attachments, and offsets of a varying shape by which the fibres anastomose with each other. Each of them has, where it passes through the inner granular layer, an oval nucleus (a "granule"), which is either inclosed within a spindle-shaped enlargement of the fibre or is only attached to it. This nucleated portion is usually described as the dividing line between the inner and the outer portion of the fibre. The inner portion ends in the nerve-fibre layer, at the internal limiting membrane, with a cone-shaped enlargement. Schwalbe, who, contrary to other authors, finds a nucleus inclosed in this cone-shaped enlargement, states also, that the cone-shaped enlargements of all the radiating fibres together form what is known as the inner limiting membrane. According to Merkel, the outer portion of the radiating fibres forms a tube-like cover for the cone-fibres and cone-granules (see later), and probably also for these same parts of the rods. The former I can affirm. The outer portion of the supporting fibres reaches to the membrana limitans externa.

The *inner limiting membrane* begins at the periphery of the connective-tissue meniscus, in the excavation of the optic papilla (Kuhnt), and is seen all over the inner surface of the retina as a transparent, vitreous, double-contoured membrane. This membrane has by several authors been described as the membrana hyaloidea of the vitreous body, but erroneously so. Schwalbe and others who make a distinction between the inner limiting membrane and the membrana hyaloidea of the vitreous body, insist that the former is not really a membrane, but is so only in appearance, being formed by the union of a double-contoured lamella lying at the base of the cone-shaped swelling of each supporting fibre. In this opinion he is strengthened by the facts that, by staining with nitrate of silver a delicate net-work of black lines may be produced on the inner surface of the retina, and that the outlines of the bases of the cones of the supporting fibres may be easily seen when viewing the inner surface of the retina. The dark lines obtained by staining with nitrate of silver are taken by Schwalbe to be identical with the outlines of the cones of the supporting fibres; where these lines appear over blood-vessels, which would prevent the supporting fibre from reaching the inner surface of the retina in a straight line, he says they do so in a curve. For a very fine net-work of lines which is

usually found in the limitans interna, just over the blood-vessels, he has, however, no explanation. Even if it be granted that, genetically, the inner limiting membrane is derived from the union of the bases of the supporting fibres, it seems to me, from my own specimens, nevertheless, to be certain that, in spite of Schwalbe's statement, the internal limiting membrane of the retina, in the eye of the adult at least, is a separate membrane. It can certainly, and with no great difficulty, be detached from the retina in pieces, leaving the bases of the supporting fibres behind. In pathological specimens I have, furthermore, seen large pieces of the inner limiting membrane perfectly detached from the retina, by exudations of a fluid or cellular nature, as a clean double-contoured membrane. This, I think, is of especial importance, since Schwalbe distinctly says: "The limitans interna is *not* a membrane which can be isolated. I willingly acknowledge that, for this reason, the usual name of membrane is a misnomer." He therefore proposes to speak of a *margo limitans*, instead of a *membrana limitans interna*. According to my opinion the limitans interna is as much an independent membrane as is the lamina vitrea of the choroid, or Descemet's membrane.

What is called the *membrana limitans externa*, however, I do not think has any right to the name of a membrane. Here I again differ with Schwalbe. This so-called membrane never is double-contoured, as it necessarily would have to be if it were a membrane; on the contrary, it is always seen as one well-marked but continually broken line. I take it to be simply the line where the supporting tissue ends, which in the outer portions of the retina surrounds all its elements. The line would, therefore, denote the outer surface of the supporting tissue, which is pierced by the free-ends of the rods and cones which project beyond it. From Schwalbe's description it is not at all evident why he speaks of an outer limiting membrane. He says: "The supporting fibres spread out in a peculiar manner between the elements of the outer granular layer, splitting up into fine fibrillæ and membrane-like lamellæ. They then form a peculiar net-work which consists of minute lamellæ, and which is perforated in many places. These meshes of the net-work correspond in size and form with the outer granules, etc. The limitans externa, which in vertical sections through the retina appears as a distinct line separating

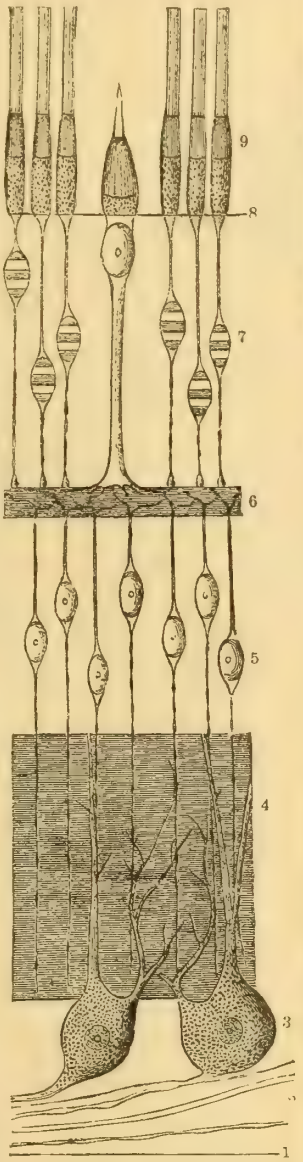


Fig. 2612.—1, Inner limiting membrane; 2, nerve-fibre layer; 3, ganglionic layer; 4, inner molecular layer; 5, inner granular layer; 6, outer molecular layer; 7, outer granular layer; 8, outer limiting membrane; 9, rods and cones.

the rods and cones from the outer granular layer, is, as is proven by isolating the supporting fibres, continuous with the latter. The supporting fibres show here a slight enlargement lying in one plane, which, after the removal of the rods and cones make in transverse sections the impression of a broken line. The membrana limitans is, therefore, *not a continuous membrane*, but perforated by round holes, just as often as there are rods and cones piercing it. Since the latter stand very close together, the openings must needs take up much more space than the remaining septa. The membrana limitans externa, therefore, appears as an extremely fine net-work, with very thin trabecules and larger and smaller meshes. The larger meshes are for the body of the cones, the smaller ones for that of the rods. From the outer surface of the limitans externa small fibrillæ are seen to spring, which are the last ends of the supporting fibres, and form what may be best compared to little baskets around the inner portions of the rods and cones."

The *optic-nerve fibre layer* of the retina, as its name implies, consists chiefly of the nerve-fibres coming from the optic nerve, and lies close to the membrana limitans interna, that is, to its outer surface. The nerve-fibres run in a general way in a radiating direction from the optic papilla toward the periphery of the retina, and more of them run upwards and downwards than toward the sides (Liebreich). Of the fibres which go to the macula lutea, but comparatively few run in a directly radiating direction from the optic papilla toward it. By far the larger number deviate from the radiating direction and form more or less concentrical arches around it. By this arrangement, of course, a much larger number of fibres can reach the macula lutea than in the simply radiating way. The convexity of these arches is upwards and downwards, and they reach the macula lutea at its upper and lower margin. The arched fibre bundles, which meet beyond the macula lutea from above and below, form something like a suture, until they finally take on a radiating direction again toward the ora serrata. Within the macula lutea itself no nerve-fibres can be distinctly made out.

Fig. 2613.—Nerve-fibres from the Retina (*a* from the ox) of Man. (M. Schultze.)

The nerve-fibres in the retina are axis-cylinders of varying thickness (as an anomaly, medullated nerve-fibres may be found), (see Fig. 2613). They frequently show varicosities which at present are considered to be artefecta, and due to the hardening agents, or, perhaps, to be simply post-mortem appearances.

The nerve-fibres are arranged in bundles, as they were in the optic nerve. Near the optic papilla several layers of bundles lie upon each other. As the fibres spread out we find only one bundle, and toward the ora serrata this one bundle becomes considerably flattened out, and interstices appear between neighboring bundles. According to Merkel, the nerve-fibres end in the ora serrata, after having formed a terminal plexus. During their course toward the ora serrata the nerve-fibres are found to divide dichotomously at very acute angles, and thus to form numerous anastomoses with each other.

Between the nerve-fibres are seen the cones of the supporting fibres, and the flat, nucleated, neuroglia cells.

In this layer, as has been stated before, the larger retinal blood-vessels are found to lie. They are mostly surrounded by a lymph-sheath.

Outward from the nerve fibre layer we find the *ganglionic cell layer*. As the name implies, the elements of this layer are, in the main, ganglionic cells. Excepting the region of the macula lutea these ganglionic cells form one layer only, although they do not always lie in the same plane. Near the macula lutea two, then three layers may be seen, and within this spot there may be eight or ten layers of ganglionic cells. Near the optic

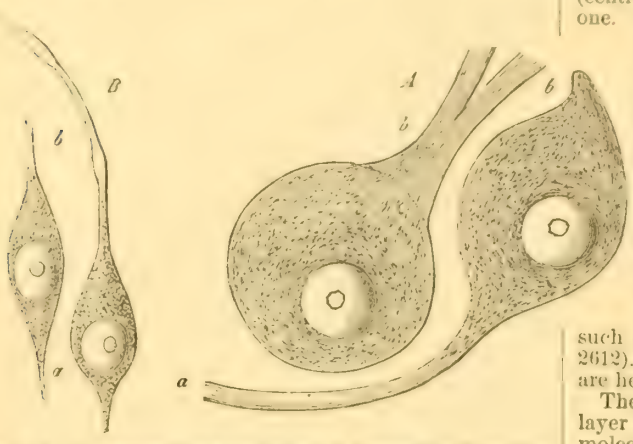


Fig. 2614.—*A*, ganglionic cells from the ox; *B*, ganglionic cells from the macula lutea of man; *a*, central, *b*, peripheral fibres.

papilla the ganglionic cells lie close to each other, only separated by the supporting fibres; the nearer the ora serrata, however, the farther they are separated from each other, and the less distinct from the neighboring layers is the ganglionic cell-layer. Even where it is a well-marked and distinct layer some of its cells may lie in the nerve-fibre layer, or in the inner molecular layer.

The ganglionic cells vary considerably in size (10 to 30 μ) and shape. They are oval, round, spindle-shaped, or of a totally irregular shape, according to the number and arrangement of their offsets (see Fig. 2614).

To each ganglionic cell goes one optic nerve-fibre, which forms its central offset. It may have one or many more peripheral offsets, except in the region of the macula lutea, where the ganglionic cells seem all to be bipolar. The peripheral offsets of the ganglionic cells are split into finer branches while passing, or after having passed, through the inner molecular layer in a direction parallel with the supporting fibres. From the inner molecular layer these peripheral fibres coming from the ganglionic cells may be seen to enter the inner granular layer, where they are in communication with the central fibres of the inner granules.

The ganglionic cells seem to be imbedded within the wing-like offsets of the supporting fibres. Neuroglia cells are also found in this layer.

The *inner molecular layer*, which lies outside of the ganglionic-cell layer, consists of a finely granulated substance, pierced by the supporting fibres at right angles and by the thickly interwoven peripheral fibres of the ganglionic cells. The granulated substance consists of a homogeneous material, in which there are numerous small vacuoles, which give it the granulated appearance. These small cavities contain, according to some authors, a fluid of a different index of refraction. Merkel, Henle, and Retzius state that these minute cavities contain small granules, which may be isolated. According to M. Schultze, the granular appearance of the inner molecular layer is due solely to small holes in a connective-tissue reticulum, through which the finest nerve-fibres take their passage. This connective tissue he calls the "spongy substance." In this way we would have two fine net-works lying within each other, the one made up of the "spongy substance," the other of fine nerve-fibres.

The *inner granular layer*, the next layer passing from within outward, consists of cells and fibres. The cells are of two kinds. These of one kind are nothing else than the nuclei of the supporting fibres, which, as stated above, are found lying in this layer. The others are numerous oval nuclei, surrounded by a small quantity of protoplasma, to which two fibres, a central and a peripheral one, are attached in a bipolar manner. Their appearance reminds one very much of that of ganglionic cells. Most authors consider them as such and the fibres as nerve fibres. The inner (central) fibre is usually thinner than the outer (peripheral) one. The central fibres are seen to dip into the inner molecular layer, and they come here in contact with the peripheral fibres of the cells of the ganglionic layer (Merkel). The peripheral fibres of the ganglionic cells of the inner granular layer pass into the outer molecular layer and go through the latter, giving off smaller branches in a radiating direction or with a "bayonet-like" bend. Merkel has furthermore succeeded in finding a direct communication between these fibres and the central fibres of the cones within the outer molecular layer. Although it is highly probable that a similar anastomosis takes place between the central fibres of the rods and the peripheral ones of the ganglionic cells of the inner granular layer, such an anastomosis has not yet been found (see Fig. 2612). The ganglionic cells of the inner granular layer are held in position by the offsets of the supporting fibres.

The next layer is the *outer molecular layer*. This layer is very thin and appears granulated like the inner molecular layer (fibrous layer, Henle). It consists chiefly of a net-work of very fine fibrillæ, in which now and then a flat cell is imbedded, whose many offsets seem to join in the formation of the net-work. Many of the fibrillæ of this net-work are undoubtedly of a nervous kind, since, as we have stated, the peripheral fibres of the ganglionic cells of the inner granular layer go into the outer molecular layer, and send off numerous branches within it. Here, also, end the central fibres of the rods and cones.

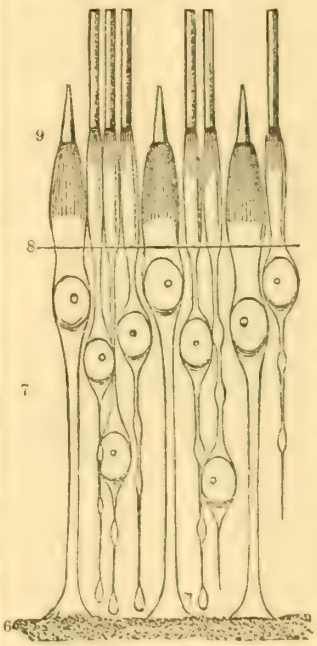


Fig. 2615.—Neuro-epithelium of the Retina of Man. 6, Outer molecular layer; 7, outer granular layer; 8, limitans externa; 9, rods and cones. (M. Schultze.)

The next outer layers of the retina form the neuro-epithelial layer of this membrane (Schwalbe); they are the rods and cones and the outer granular layer (see Fig. 2615).

The cones as well as the rods, as seen in Fig. 2615, are divided into an outer and an inner portion; the inner portion of both kinds of elements shows a further subdivision by the limitans externa.

The outer portion of the cones is much smaller than the inner one, and is divided from it by a sharp line, but it has also a conical shape. The much larger inner portion is longer as well as broader than the outer one. H. Mueller gives the length of a whole cone as 32 to 36 μ, of which 15 to 25 μ belong to the inner portion.

The outer portion of the cones, which appears homogeneous, is made up of little disks, into which it is seen to break up after death. These disks are held in position by a very fine membrane (M. Schultze). The inner portion of the cones is usually granulated. A longitudinal striation, which is sometimes seen on this portion, is due to the formation of folds in the sheath which surrounds them (Merkel). Having passed the limitans externa inward, the cone has

a spindle-shaped enlargement, in which a nucleus, the cone-granule, is imbedded. Then it is drawn out into a thick fibre, the cone-fibre, which, with a slight swelling, enters the outer molecular layer, and then sends smaller fibres into it. The outer part of the inner portion of each cone contains an elliptic body, the "ellipsoid," whose nature is at present unknown. The outer portion of each rod is cylindrical, and it is a little thinner than the slightly cone- or cylinder-shaped inner portion. The rods are also separated by a sharp line. The length of the rods is from 40 to 60 μ (M. Schultze) (see Fig. 2616).

When fresh, the outer portion of the rods is perfectly homogeneous. After death it (as well as the inner portion) shows sometimes a longitudinal striation which is caused in the same manner as that on the cones, by folds in the sheaths. Later on, the outer portion of the rods also splits up into thin, round disks. The inner portion of the rods appears homogeneous or slightly granulated. After having passed the limitans externa on its way inward, the inner portion of the rod becomes thinner and forms the rod-fibre. This fibre, at some point between the limitans externa and the outer molecular layer, becomes considerably thicker, and here contains an oval nucleus, the rod-granule.

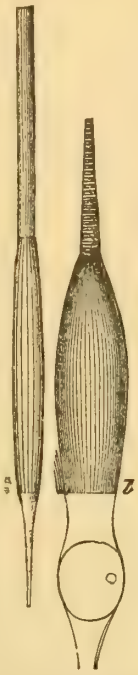


Fig. 2616.—A Rod and a Cone from the Retina of Man. *l*, Limitans externa.

Inward from this enlargement it becomes thinner again, until it forms another slight enlargement, just before entering the outer molecular layer. The rod-granules often show a horizontal striation (see Fig. 2612).

Rod- and cone-granules form, together with the fibres, the elements of the outer granular layer. Fibres, granules, rods, and cones are ensheathed in a fine membrane coming from the supporting substance, which, tube-like, surrounds them (Merkel). While the cone-granules lie always close to the limitans externa, the rod-granules lie at a varying distance from it, so that these granules form numerous layers.

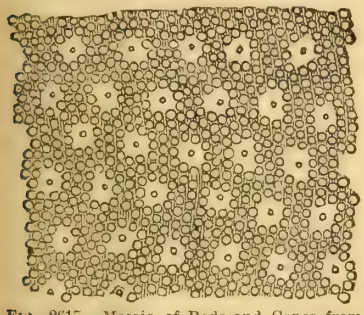


Fig. 2617.—Mosaic of Rods and Cones from the Peripheral Portion of the Retina.

The outer portion of the rods is alone stained by the retinal purple, as stated above (Kuehne).

In a plane view of the outer surface of the retina, the optic transverse sections of the rods and cones form a fine mosaic. The arrangement of the latter differs, however, according to the portion of the retina from which it is taken (see Figs. 2617 and 2618). Thus, for instance, we find near the region of the macula lutea each cone surrounded by a single ring of rods, while in a more peripheral portion a number of rings of rods surround one cone.

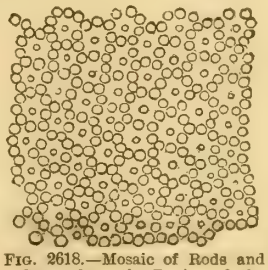


Fig. 2618.—Mosaic of Rods and Cones from the Region of the Macula Lutea.

From the foregoing it is seen that we know of a well-established connection between the optic nerve-fibres and the cones, and thus also between the cones and the centre of vision. While such a direct communication between the optic centre and the rods very probably, even almost certainly, exists, it has thus far escaped satisfactory demonstration. The way in which the communication between the cones and the optic nerve takes place is in short the following: The optic nerve-fibre enters a ganglionic cell. From this one or more fibres are given off in a peripheral direction, which go into the inner molecular layer. In this layer they anastomose with the

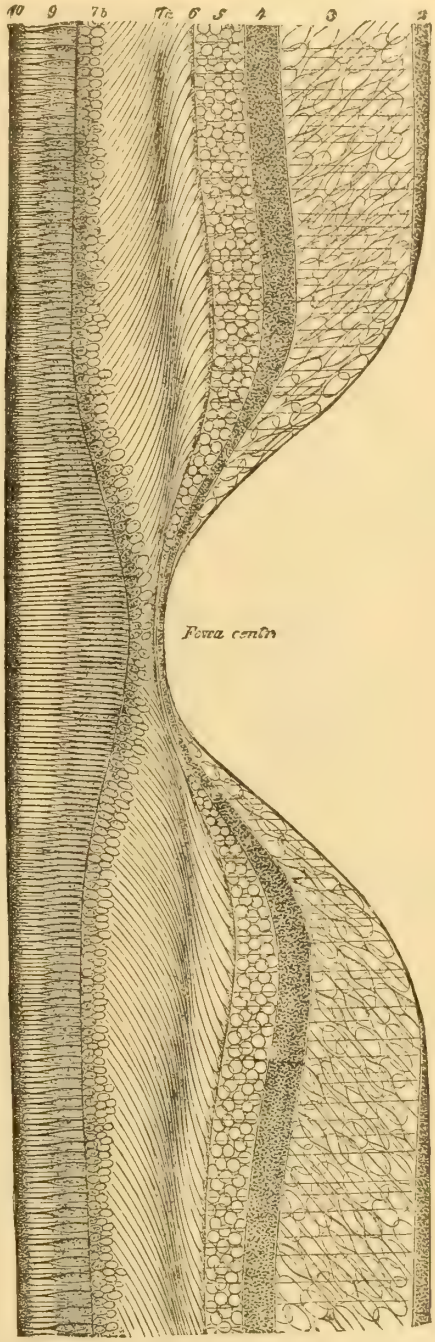


Fig. 2619.—Schematic Section of Macula Lutea and Fovea Centralis. 2, Nerve-fibre layer; 3, ganglionic cell-layer; 4, inner molecular layer; 5, inner granular layer; 6, outer molecular layer; 7*a*, outer fibre-layer; 7*b*, outer granular layer; 9, rods and cones; 10, pigment-epithelium layer. (M. Schultze.)

central fibres of the ganglionic cells of the inner granular layer. As stated above, these ganglionic cells give off peripheral branches which pass into the outer molecular layer and there form a fine net-work. The outer molecular layer is also reached by the central fibres coming from the rods and cones. The latter, that is, the cone-fibres, give off fine fibrillæ in this layer, which, as Merkel has found, anastomose undoubtedly with the peripheral offsets of the ganglionic cells of the inner granular layer.

The general structure of the retina, as it has been described above, is very materially modified in three regions: (1) where the retina joins the optic papilla; (2) in the macula lutea and fovea centralis, and (3) in the peripheral portions and the ora serrata.

The retina does not begin in the same way on all sides of the optic papilla. Schwalbe states that on the outer side it begins with a vertical line, while on the nasal side it begins with an oblique line, so that the outer layers, especially the rods and cones, come closer up to the papilla than do the inner layers. This arrangement, of course, necessitates that in this portion the rod- and cone-fibres, instead of running in a vertical direction, must run in an oblique one. Kuhnt, furthermore, has drawn attention to the fact that in the normal eye there is a small space between the optic nerve and the retina which is free from rods and cones. In this space a small amount of connective tissue lies between the pigment-epithelium and the nerve-fibre layer. This tissue he calls the "intermediary" tissue. Its quantity is larger on the nasal side than on the side of the macula lutea.

The changes in the structure of the retina are very marked and important in the region of the macula lutea and fovea centralis (see Fig. 2619). In the macula lutea no rods are found between the cones. The latter are thinner and longer, and stand close together. The nerve-fibre layer ends at the periphery of the macula lutea, according to H. Mueller, at the nasal side, 250 μ from the centre of the fovea centralis; at the temporal side, 350 μ; above and below, 180 μ from it.

The ganglionic cell-layer becomes considerably thicker near the macula lutea, and is thickest a little distance from the fovea centralis. At its margin, about where the nerve-fibre layer ends, the ganglionic cell-layer, which now lies directly outward from the limitans interna, becomes rapidly thinner. In the centre of the fovea centralis it is so thin that some authors deny its existence there. It seems, however, that even in the centre of the fovea centralis ganglionic cells are not wanting. As already stated, the ganglionic cells in this region are no longer multipolar; they have here only one central and one peripheral fibre, which join them at the opposite poles. They are, therefore, all bipolar.

The inner molecular layer is but little thicker in the macula lutea than in other regions of the retina. At the margin of the fovea centralis it becomes rapidly thinner, and disappears altogether within it.

The inner granular layer also gains considerably in thickness in the macula lutea. Not only are there more granules, but these are also larger than in other portions of the retina. Rapidly decreasing in thickness within the fovea centralis, this layer becomes so intimately connected with the ganglionic cell-layer, that it is difficult to trace them separately. The axis of the granules is here no longer perpendicular to the surface of the retina, but it lies obliquely in a direction toward the centre of the fovea centralis.

The outer molecular layer is changed in the macula lutea in such a manner that the granulated substance gradually disappears while the fibres (fibrous layer of Henle) are considerably longer and more prominent. These fibres, which in other regions run in a more or less vertical direction, assume here a bayonet-like bend in such a manner that the horizontal branch is longer than the more or less vertical one, and is the longer the nearer it is to the centre of the fovea centralis.

The cone-fibres, to get to the cones, must also run in an oblique direction, and the axis of the granules of the outer granular layer is changed accordingly.

The limitans externa is slightly bent inward within the fovea centralis. The membrana limitans interna forms a line with a very deep convex bend outward. Mueller's supporting fibres seem to be absent in the fovea centralis, and but poorly developed in the macula lutea.

From the foregoing it is evident that the retina is considerably thicker in the macula lutea than elsewhere (except near the optic papilla), and that this is chiefly due to the increase in thickness of the ganglionic cell layer, the inner molecular and inner granular layers, and the fibrous portion of the outer molecular layer. On the other hand, the nerve-fibre layer and outer granular layer are thinner, the former even disappearing altogether in the fovea centralis, as does also the granulated substance of the outer molecular layer. The centre of the fovea centralis is very thin, and, as far as known, it consists only of the cones, limitans externa, outer granular layer, fibre-layer, inner granular layer, ganglionic cell-layer, and the membrana limitans interna. Thus the nervous elements very considerably predominate in the macula lutea and fovea centralis over the supporting and non-nervous substances.

As stated above, the retina ends peripherically with a scalloped margin, the *ora serrata*. In the direction toward its periphery this membrane becomes gradually thinner. The nervous elements disappear more and more, while the supporting substance appears more prominent. First the rods and cones and the nerve fibres become less numerous, until they finally disappear altogether, and in the same gradual manner all other layers disappear (the inner granular layer the last), except the inner molecular layer, which suddenly disappears close to the ora serrata. This causes a more rapid diminution in the thickness of the retina in this region (Schwalbe).

The retina of old people frequently shows a further peculiarity in this region. It has been especially studied by Iwanoff, and by him has been described as "œdema" of the retina. Nettleship gave it the more appropriate name of the "cystoid degeneration" of the ora serrata. The change consists in the appearance of cavities of different size and shape, but generally of an oblong form, which coalesce with each other within the tissue of the retina. They are separated from each other by supporting fibres and the other elements of the retina, which seem to be pressed aside. These cavities may occupy the thickness of one layer only, or they may extend from the limitans externa to the nerve-fibre layer. I have never seen any of them reaching the inner or outer surface of the retina. Whether they are filled with serum during life, as is probable, is not known.

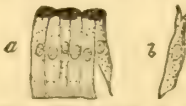


FIG. 2620.—Cells of the Pars Ciliaris Retinæ of Man. *a*, In conjunction with pigment-cells; *b*, isolated. (H. Mueller.)

Although the nervous elements of the retina end at the ora serrata, a portion of this membrane can be traced farther on, covering the inner surface of the ciliary body. This is the *pars ciliaris retinæ*. It consists of a single layer of cylindrical cells, which are considered to be the continuation of the supporting fibres of the retina (see Fig. 2620).

These cells gradually increase in height toward the insertion of the iris. They appear granular, and their oval or round nucleus usually lies near their base. Toward the vitreous body they are round or cone-shaped. Sometimes they end with short offsets. On the inner surface of this layer of cells a fine vitreous membrane is sometimes found, which probably is the continuation of the membrana limitans interna of the retina.

We have so far not spoken of the last layer of the retina on its outer surface, the pigment-epithelium layer. As stated before, this layer is now considered to form a part of the retina. Its physiological nature, by the researches of Kuehne, Boll, and others, has of late been proven to be that of a gland-like organ, which secretes the retinal purple (rhodopsine).

The pigment-epithelium forms one layer of thin pavement-epithelium cells. They are hexagonal, with a certain regularity, although round cells, or cells with less or more than six angles may be met with (see Fig. 2621).

These cells contain a varying amount of pigment gran-

ules within their protoplasm. The quantity and color of this pigment varies not only in different eyes, but also in one and the same eye considerably. Their nucleus, which is rounded or oval, and which lies usually in the centre, appears unpigmented. Even in negroes' eyes its position is clearly seen by a lighter spot. In some cells two or more nuclei are found. The pigment-granules are more numerous near the retinal surface of the cells than near the choroidal one. The latter is even often free from pigment. Many of the pigment-granules are seen with a high magnifying power to be crystals (fuscine, Kuehne). Toward the retina the pigment-epithelium

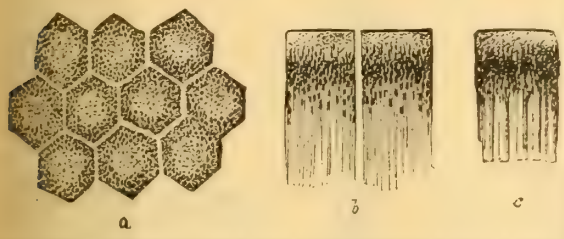


Fig. 2621.—Pigment-epithelium Cells from the Retina of Man. *a*, Plane view; *b*, side view, showing their offsets toward the retina; *c*, a cell to which the outer portions of some rods are attached. (M. Schultze.)

cells have fine offsets, which pass in between the outer portions of the rods and cones, but are not attached to them. They also contain a varying amount of crystals of fuscine. The influence of light changes the length and shape of these offsets and the distribution of the fuscine crystals within them. It has of late been found by Engelmann that in the dark the inner portion of the cones is considerably stretched toward the pigment-epithelium layer, and that at the same time the offsets of this layer are very short. When light is suddenly admitted the inner portion of the cones contracts toward the limitans externa, and the offsets of the pigment-epithelium cells become considerably elongated. Thus the microscopical picture will be influenced by the amount of light which entered the eyeball before its death.

The structure of the arterioles of the retina shows nothing peculiar. The capillaries, according to Schwalbe, are not, as usual, one endothelial tube only, but they consist of two tubes, one of which lies loosely within the other. A similar arrangement is seen on the venous blood-vessels. At the ora serrata no communication takes place between the retinal and the ciliary arteries.

The outer endothelial tube of the capillaries just mentioned is a lymph-sheath. Such a lymph-sheath may be found around all the retinal veins and capillaries by injecting them from the pia mater. The arteries seem to possess such lymph-sheaths in a more irregular manner. For, while in the veins and capillaries the lymph-stream is severed from the blood-stream by an endothelial membrane only, the lymph-sheaths of the arteries are found to lie outside of their muscular coat. Injections, made from beneath the pia-mater sheath, also fill a number of fissures in the nerve-fibre layer of the retina, which pass into it from the optic papilla in a radiating direction. These lymph-channels are in connection with those found in the pia-mater septa of the optic nerve.

Adolf Alt.

OPTOMETRY, from ὀπτ-, root of ὄψομαι, fut. of ὁράω, to see, and μέτρον, measure—signified, in its older use, the measurement of the range of vision (*die Gesichtsweite*), and the earlier optometers were instruments designed for this single purpose. With the broader and more accurate knowledge of the physiology and pathology of vision, acquired mainly since the middle of the present century, quantitative methods have been applied to the investigation of other visual functions, and we now recognize, as parts of one general subject, the measurement (1) of the acuteness of the visual perception of form (eidoptometry), (2) of the perception of light (photoptometry), (3) of the perception of colors (chromatoptometry), (4) of the extent and limitations of the visual field (perioptometry), (5) of the accommodative and refractive states of the eye (dioptometry), and (6) of the position and movements of the eyeballs (ophthalmostatometry and ophthalmotropometry).

Eidoptometry—from εἶδος, form—deals with the measurement of the acuteness of the visual perception of form—*visus*, V.; German, Sehschärfe, S. Assuming an adequate and, within certain limits, uniform illumination, together with a sharply defined retinal image, and excluding such variations as may arise from imperfect light- or color-perception, the physiological limit of the acuteness of vision is determined by the fineness of texture of the mosaic formed by the cones of the retina at the fovea centralis of the macula. Let *d d* (Fig. 2622, B, from Helmholtz) represent the mosaic of retinal cones at the macula, and *a*, *b* and *c* the images of three vertical bars of a grating for which the eye is accurately accommodated. If the grating is removed to such a distance from the eye that the image of each bar shall not much exceed the diameter of one of the retinal cones the several images will appear more or less distorted or beaded, according as they happen to fall upon one or another, or perhaps upon two, of the cones lying nearest to their tracks. With the bars and interspaces of the grating each of a width of .4167 millimetre, the appearance shown at A begins to be manifest when the grating is removed to a distance of 1.1 to 1.2 metre (Helmholtz). This corresponds to a width of about .005 millimetre for each bar of the grating as pictured on the retina, and to a visual angle of about 1.2′; it also indicates a pretty close approximation of the width of the image to the actual diameter of the retinal cones at the macula (.0045 to .0054

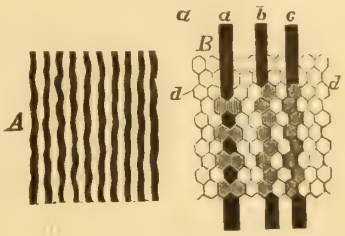


Fig. 2622.

millimetre). Observations on the smallest angular distance at which two fixed stars of lesser magnitude (Hooke) or the bars of a grating (Helmholtz) can be positively distinguished by the naked eye, point also to an angle of 1′ as about the limit of distinct retinal perception.

The first serious attempt to apply a system of exact measurement to the determination of the acuteness of vision was made by E. Jaeger. Jaeger's *Strich-scale* (see Plate XXI.)[1] consists of a series of lines diminishing in length and in width, in geometrical progression, from No. 1, with a width of .4597 Vienna inch, to No. 80, with a width of .0037 inch; the measure of the acuteness of visual perception is the smallest white interspace which can be positively recognized at the distance at which the observation is made. Thus a normally acute eye sees No. 5 at 100 feet; No. 30 at 20 feet; No. 80 at 1 foot, etc. Unfortunately, the ratio of gradation adopted by Jaeger is an entirely arbitrary one, so that the numbers obtained in different cases, though readily comparable one with another, do not indicate the relation of individual measurements to the normal. Moreover, the determination turns entirely on the unchecked statement of the person examined, that he sees the lines down to a certain place in the scale. The results of the very numerous and characteristically careful measurements made by Jaeger with this scale point to a visual angle of about 1′ as the limit of distinct recognition of the individual lines by a normal eye.

Snellen[2] was the first to work out a system of measurement adapted to the needs of the ophthalmic practitioner (see Plate XXII.). Assuming a visual angle of 1′ as the average limit of distinct vision in the normal eye,

Snellen constructed, upon this basis, a number of capital letters of sizes corresponding to seventeen different distances, varying from 200 Paris feet (No. CC.) to 1 foot (No. 1.). Each square letter, viewed from the distance indicated by its number, subtends a visual angle of 5′, and each letter is made up of lines subtending each an angle of 1′. The ultimate elements from which the several square letters are constructed are small squares, each subtending an angle of 1′, and twenty-five of these smaller squares are equal in area to the square in which the letter is inscribed. Only such letters are used as can be drawn approximately within the compass of a square, and even of these scarcely any two are of absolutely equal legibility; still, the difference is not so great as to impair the usefulness of the method, and the recognition of only a part of the letters of any number in the scale affords the means of making a finer discrimination than when only the more easily recognizable letters are used. Furthermore, certain of the letters appear under characteristically modified forms when viewed by an astigmatic eye, D sometimes looking like B, O like the numeral 8 or like S, H like N, V like W, etc. The test of perfect recognition of form is therefore the correct naming of all the letters at the distance corresponding to the number. Representing the greatest distance at which the letters in any given line are distinctly seen by d, and the greatest distance at which the same letters ought to be seen by a normally acute eye by D, the measure of the acuteness of vision in any particular case is expressed in the simple fractional form $\frac{d}{D}$. The adoption of this simple and altogether excellent system was immediate and general; it remains the only method suited to the daily requirements of the practitioner.

The system of Snellen admits of but little further development; simple geometrical figures, or representations of familiar objects of characteristic outlines, also the Arabic numerals, are of use in examining children or illiterate persons, and some of the letters peculiar to the Greek and to the Russian alphabets have been added for the use of persons of those nationalities. The substitution of numbers based on distances taken in metres instead of in Paris feet was made by Snellen in 1875.[3] The simpler form of letters known to printers and sign-painters by the inappropriate name of Gothic has been tried instead of the block-letter used by Snellen, and a regular ratio of gradation in geometrical progression[4] has been proposed in the place of his somewhat arbitrarily selected series of numbers* (see Plate XXIII.); a notation in tenths, and therefore capable of being expressed in simple decimal form,[5] has also been somewhat extensively used.

For testing the quickness, as well as the accuracy, of the perception of form, especially at short distances, printed texts are in general use; such texts have been published by Jaeger[6] in a great number of different languages, and in various kinds of type. Jaeger's smallest type (No. 1, = "gem" or "brilliant"), read fluently at at a distance of one foot, is a pretty severe test of normally acute vision conjoined with good power of accommodation for the usual reading distance. Jaeger's numbers have no especial significance, beyond the fact that the higher numbers indicate the larger sizes of letters; still it is more convenient, and, on the whole, more accurate to note the number of the type than to use the somewhat variable nomenclature of the type-founders.

Photoptometry—from φως, light—is comparatively little employed in the ordinary routine of ophthalmic practice, yet it is not without positive value in the diagnosis of impaired function of the retina. Two principal types of photoptometers have been used, each of which has its special applications.

A rapidly rotating disk, upon which a smaller or larger sector (Masson),[7] or a row of short lines arranged along a radius (Donders)[8] is depicted in black upon a white ground (Fig. 2623), or in white upon a black ground, presents the appearance of a shaded band, or of a number of

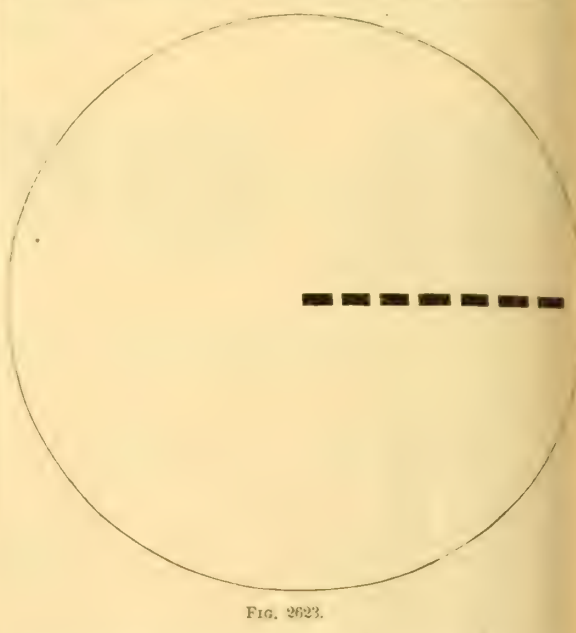


Fig. 2623.

concentric shaded rings, diminishing in intensity from the centre to the periphery of the disk. Whenever the width of the black line is less than $\frac{1}{100}$ of the circumference of an imaginary circle drawn through it, the shaded ring is ordinarily so faint as to be no longer perceived by a normal eye in average daylight within doors (Helmholtz).[9] The measure of the acuteness of light-perception, in any particular case, is obtained by simply noting how many of the concentric rings are seen when the disk is rapidly rotated; the proportion of black to white or of white to black in each ring is the quotient of its circumference divided by the width of the black stripe.

The photoptometer (*Lichtsinnmesser*) of Förster[10] is a closed box one foot long, eight inches wide, and six inches high; at one end are two openings for the eyes, and a window, about two inches square, covered with thin white paper. Behind this paper diaphragm is a small lantern, containing a candle of standard illuminating power. The quantity of light which enters the box is determined by the area of the paper diaphragm, and this is regulated by means of two notched plates of metal sliding over each other so as always to leave a square opening whose area may be read off from a graduated scale. At the opposite end of the box is placed the test-object, a card divided into vertical black and white bars of from one to two centimetres in width. The measure of the acuteness of the perception of light (L) is h, the smallest area of the window required for the recognition of the stripes by a normal eye, divided by H, the smallest area which suffices for the recognition of the same stripes by the eye under examination. According to Förster's observations, made with the instrument of the dimensions just described, h = two square millimetres, so that $\frac{h}{H} = \frac{2}{H} = \frac{1}{\frac{1}{2}H}$.

Chromatoptometry—from χρῶμα, color—as applied to the diagnosis of defective color-perception, has been noticed in the article Color-blindness. Approximate measurements of the acuteness of color-perception may be made with Snellen's test-letters, printed in vivid colors on a black ground; or the white letters may be strongly

* The card of test-letters shown in Plate XXIII. is constructed on the basis of a constant ratio of gradation, $\sqrt[5]{\frac{1}{10}} = .794$; the Arabic and Roman numerals denote, respectively, the distances in metres and in feet at which the letters should be distinguished by a normal eye. For convenience, the feet have been taken equal to one third metre, which is a little more than the Paris foot, as used by Snellen in the letters shown in Plate XXII. In the arrangement here reproduced but a single letter is given for each number of the scale; such a series is very convenient as a guide to the particular row of letters which the patient may be expected to read. The construction of the individual letters is slightly varied from that adopted by Snellen; the result aimed at in this change is the somewhat more uniform legibility of the different letters.

PLATE XXI.

illuminated with one of the colors of the spectrum. The measure is expresssed in Snellen's notation, $\frac{d}{D}$, taking for D the distance at which an eye of normal acuteness of vision and normal color-perception recognizes the same letters which the patient sees at the distance *d*.

Förster's photoptometer may be used for measuring the acuteness of color-perception by interposing a plate of glass, of the color for which the eye is to be tested, between the candle and the paper diaphragm. The value of *h*, in the fraction $\frac{h}{H}$, must be found, by experiment, for eyes of normal visual acuteness and perfect color-perception.

The revolving disk may be used for the same purpose, by painting a sector or broad line of the required color, or two sectors of different colors which form a combination-color when the disk is rotated,[11] on a black ground.

The principle of simultaneous contrast may be utilized as a delicate qualitative test of color-perception. Thus the shadow cast by any small opaque object upon a white ground appears of a color complementary to that of the light. The test is easily made, in the dark room appropriated to ophthalmoscopical examinations, by placing a sheet of colored glass in front of the lamp, and directing the attention of the patient to the color of the shadow cast by a pencil upon a white screen.

Perioptometry—from περί, around—is properly the measurement of the limits of the visual field in its several dimensions; it includes also the detection and measurement of defects in the field of vision (scotomata), wherever they may be situated. The simplest, and for many purposes the best method of testing the central portions of the field, say, within the limits of 45° in all directions from the point of fixation, is by means of a black-board or a sheet of dark (blue) or white paper, upon which a central point of fixation is marked by a small cross, +. The patient is placed at a measured distance from the board (usually one foot, or, if strongly myopic, at a shorter distance), and is directed to look with one eye (the other being covered) at the central cross. A bit of chalk or crayon, fixed to the end of a short wand of the same color as the board or paper, is then moved from the periphery toward the centre of the field, until it reaches a point at which it is seen by the patient. The observation is then repeated for other ocular meridians in succession, until the boundaries of the field have been determined at a number of points sufficient to admit of drawing a continuous outline through them.[12]

For mapping the periphery of the field, when of nearly normal extent, a plane surface is insufficient, and for all

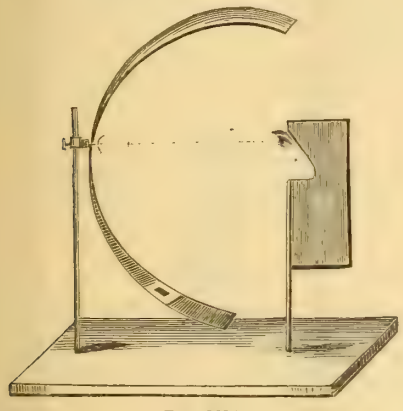


Fig. 2624.

distances beyond 45° from the point of fixation the distortion of the peripheral portions of the chart becomes excessive. For the projection of the entire field, with all its parts in due proportion, we require a hemispherical background instead of a plane surface, and to this end we make use of the *perimeter*,[13] which is merely one-half of a flat hoop, upon the inside of which the position of any point of the fundus, lying in the meridian corresponding to the direction of the hoop, may be marked (Fig. 2624). By turning the hoop about a pivot, it is brought into the necessary position for the observation of the extent of the field in different meridians, and each point, as determined, is transferred to a blank chart printed, in concentric circles, in polar projection (Fig. 2625).

For the direct mapping of the visual field in its entire extent the perimeter of Scherk[14] may be used; it consists simply of a hollow hemisphere, of one foot radius,

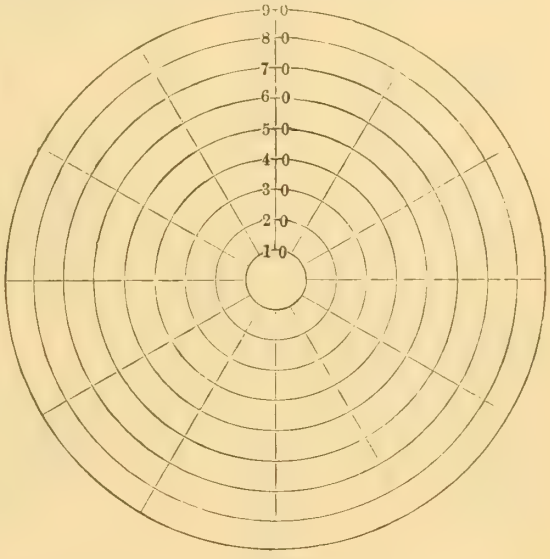


Fig. 2625.

blackened on the inside. The eye to be examined is placed at the centre of the sphere, and the limits of the field are marked with chalk in the same manner as when the black-board is used. To secure a better light for the observation the hemisphere is made in separable halves, and the mapping is done for one-half of the field at a time.

Most of the perimeters, as found in the shops, have an arrangement of cords and pulleys, by means of which the test-object is moved along the arc;[15] this is a complication of at least doubtful advantage. A further complication consists in a self-registering apparatus, analogous to that employed in the "conformateur," used by hatters to prick a small diagrammatic outline of the shape of the head. Carter has made the instrument smaller by cutting off one-half of the arc, thus reducing it to a quadrant.[16] One of the latest modifications is by Dyer, who has constructed a hemisphere of a continuous spiral of stiff wire, upon which the test-object is made to travel by turning a crank.[17] For practical utility the arrangement in use at the Utrecht clinic is unsurpassed; it consists of a black-board, about three feet square, to the centre of which is pivoted a half-hoop of one foot radius; the black-board serves for the direct mapping of limitations of the field within the limits of 45° from the point of fixation, and the arc is used for peripheral measurements. The divisions of the arc between 0 and 45° are projected upon the board in circles whose radii are equal to the tangents of the respective angles.[18] The half-hoop of the perimeter is usually made of brass, and is quite heavy; one-half of a hoop of a cheese-box, stiffened at the back by a piece of thin board sawed to the proper curve, answers every purpose in practice; the points are determined by moving a bit of chalk or of white card-board along the blackened arc.

Instead of the small square of card-board a small electric lamp, the intensity of which may be regulated at will by varying the internal resistance of the battery, may be used in determining the limits of the visual field in cases of cataract or other obscuration of the media.

For testing the limits of the field for color-perception, small pieces of colored card-board, usually one centimetre (.4 inch) square, are used instead of the bit of chalk or squares of white card. A small convex mirror of very short radius of curvature, such as the bulb of a thermometer, may also be used to reflect white or colored light from a lamp placed a little above and behind the patient's head.

The perception of form in the peripheral regions of the retina is tested by means of two small black squares on a white ground, with an interspace equal to one of the squares (Fig. 2626). These squares, of sizes corresponding to the thickness of the limbs of Snellen's test-letters (Nos. XX. to C.), are moved along the arc of the perimeter toward the centre of the field, until the white interval is seen between the two black dots.

Dioptometry (from διά, through).—Optometry of writers of the last, and of the first half of the present century, has to do with the eye considered as a dioptric instrument, and more especially with the detection and measurement of the different anomalies of refraction and accommodation. Furthermore, it deals rather with the question of the adaptation of the eye, as a whole, to the requirements of vision, than with measurements of the individual parts of the eye (ophthalmometry). The detection, measurement, and correction of the several anomalies of refraction and accommodation are treated in this Handbook under the titles, Accommodation and Refraction, Asthenopia, Astigmatism, Hypermetropia, Myopia, and Presbyopia. It remains to notice, in this place, a few special methods of dioptometry.

Dioptometry is either objective or subjective, according as the investigation turns upon observations made by

Fig. 2626.

the examiner or by the person examined. The objective methods are of the wider applicability, inasmuch as they may be employed in cases in which the patient is incapable of making accurate observations, or of accurately reporting his observations; subjective determinations have, on the other hand, the special advantage that they are actual measurements of the function performed by the eye under examination. Objective examination affords, in many cases, the readiest means of discovering and of approximately measuring a refractive anomaly, and is often of great service to the examiner by guiding him in the conduct of such tests as require the active co-operation of the patient.

In the objective investigation of ametropia the chief dependence is upon the ophthalmoscope; the different methods of conducting such examinations have been described under that title (see Ophthalmoscope). A second method, based upon the observation of the images formed by reflection at the anterior surface of the cornea, and therefore suited to the detection of asymmetry or irregularity of the first and most important of the refracting surfaces of the eye, demands notice in so far as it may be employed in clinical investigations.

The image of a luminous point or small flame, as it is seen mirrored by a cornea of irregular curvature, undergoes conspicuous changes of form according as the reflection is from one or another part of the corneal surface. This is especially conspicuous in irregularity of contour resulting from the cicatrization of a wound or of an ulcer, or from distortion of the corneal tissue when softened by disease. It is also very characteristic in keratoconus (conical cornea), in which affection the image remains nearly in one position, at the rounded vertex of the cone, from whatever direction the light is made to fall upon it. When the light falls upon the cone from the side, two images are often seen, the one small and nearly central, corresponding to the vertex of the cone, the other lateral and elongated, as formed by reflection at the side of the cone nearest the light. In regular astigmatism, in which asymmetry of the cornea is ordinarily the most important factor, the image of the point of light appears drawn out in a line corresponding in direction to one of the two principal meridians; if two lights are used, their images will be seen to be appreciably nearer together when the two lights are so adjusted that they both lie in the plane of the corneal meridian of greatest refraction than when they lie in the plane of the meridian of least refraction. Inasmuch as the distance which separates the two images is dependent on the radius of curvature of the corneal meridian in which they lie, it is possible, by measuring this distance, to obtain data for calculating the radius of curvature. The ophthalmometer of Helmholtz,[19] adapted by Donders and Middleburg[20] to the investigation of the curvature of the cornea in its different meridians, is an instrument by the aid of which such measurements may be made with almost the accuracy of an astronomical observation.

If a small square of white card-board is held at a distance of a few inches in front of an eye, the image seen reflected in the cornea will appear more or less distorted whenever the corneal curvature is either irregular or

Fig. 2627.

asymmetrical. The most striking distortions are observed in conical cornea and in astigmatism; in the former condition the four straight sides of the card appear incurved in the image, in the direction of the vertex of the cone (Fig. 2627); in the latter condition the square card is reflected as a parallelogram and a circular card as an oval.

This experiment is further developed in the disk (keratoscope) of Placido,[21] a circular card about twenty-three centimetres (nine inches) in diameter, with concentric rings painted in black and white upon the side turned toward the eye to be examined. The observer, looking through a hole in the centre of the card, sees an image formed by reflection from nearly the entire surface of the cornea; the effect of any asymmetry or distortion of the reflecting surface is revealed by a characteristic asymmetry or distortion of the image (Fig. 2628).

In the "astigmometer" of De Wecker and Masselon[22] a square black card with a white border 1.5 ctm. wide is held before the eye to be examined, and the form of the image of the white border noted (see Fig. 2627).

The ophthalmometer of Javal and Schiötz (Fig. 2629)[23] is a simplification of the Donders-Middleburg modification of the ophthalmometer of Helmholtz; instead of

Fig. 2628.

lights, special test-objects of white card-board or enamelled metal are used, and the images are viewed through a small telescope which contains a weak prism, by means of which the images are doubled and brought into such relations to each other that their mutual distance can be ascertained at a glance (Fig. 2630). The several parts of the instrument are so proportioned that the ametropia for any meridian may be read off in dioptrics without the trouble of making calculations.

The *arc keratoscopique* of De Wecker and Masselon (Fig. 2631)[24] is a simplification of the ophthalmometer of Javal and Schiötz; a number of small white disks, arranged at equal distances upon a blackened arc like the arc of a perimeter, give reflections in which the inter-

CC

A

C

C E

LXX

G L N

L

P R T 5

XL

V Z B D 4

XXX

F H K O S 3

XX

U Y A C E G L 2

spaces are equal when the curvature of the cornea is regular (Fig. 2632), but unequal when the curvature changes from the periphery toward the centre (Fig. 2633). The

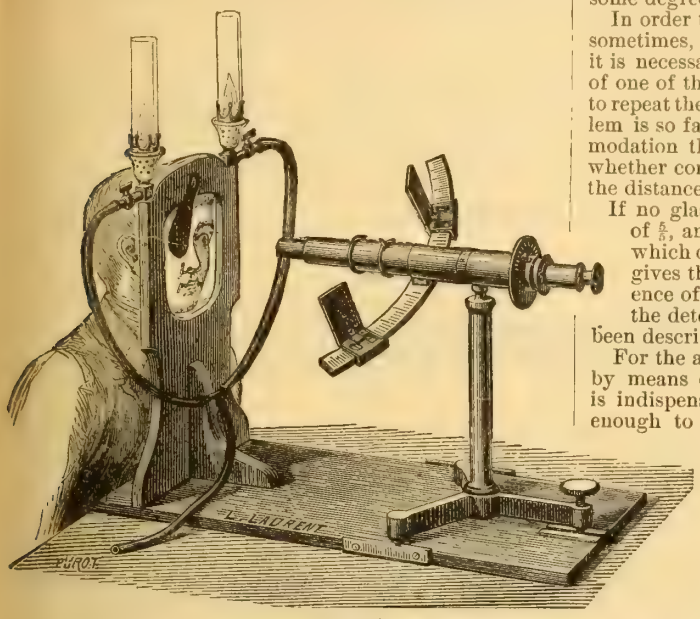


Fig. 2629.

instrument is especially designed for the detection and measurement of conical cornea.

In subjective dioptometry we distinguish methods which turn upon the recognition of the forms of test-objects, such as the test-letters of Snellen, and methods in which the accurate recognition of form is not required.

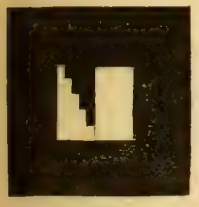


Fig. 2630.

In any case in which the acuteness of vision is normal, the detection and measurement of simple ametropia (H or M) by means of trial-glasses used in connection with the test-letters of Snellen is an exceedingly simple matter. Having placed the patient at a measured distance of say five metres from the card of test-letters, we note the smallest line of letters which he is able to read correctly with the unaided eye. If by this test we find $V = \frac{5}{5}$, the presence of myopia of any grade in excess of .2 dioptric ($\frac{1}{500}$) is excluded, and the eye is either practically emmetropic or hypermetropic with accommodative power in excess of its hypermetropia (A > H). To decide between these two possible conditions we place a weak convex glass before the eye and note whether there is any falling off in the acuteness of vision at the distance of the test-card. If we still find $V = \frac{5}{5}$, the presence of some degree of hypermetropia is established, and we exchange the convex glass for some other glass of greater power, until we have hit upon the strongest convex glass through which V remains at the normal standard, $\frac{5}{5}$. The value of this convex glass in dioptrics is the measure of the manifest hypermetropia (Hm).

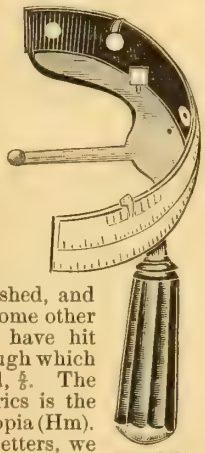


Fig. 2631.

Whenever, by the use of the test-letters, we find $V < \frac{5}{5}$ we suspect the presence of myopia, and proceed at once to try the effect of a weak concave glass. If V is improved by this glass we try stronger glasses in succession, until we have found the weakest concave glass through which $V = \frac{5}{5}$. The value of this concave glass in dioptrics is the measure of the myopia (M), or possibly of the myopia supplemented by some degree of abnormal tension of the accommodation.

In order to measure the total hypermetropia (Ht), and sometimes, also, to obtain the true measure of a myopia, it is necessary to bring the eye under the full influence of one of the stronger mydriatics (see vol. iii., p. 781), and to repeat the examination with the test-letters. The problem is so far simplified by the suppression of the accommodation that it is now only a question of what glass, whether convex or concave, raises V to its maximum at the distance of the test-card.

If no glass suffices to raise V to the normal standard of $\frac{5}{5}$, and especially if the patient is in doubt as to which of several glasses of somewhat different power gives the best visual result, we may suspect the presence of astigmatism. The special methods used for the detection and measurement of astigmatism have been described under that title.

For the accurate and rapid measurement of ametropia by means of trial-glasses, a very full series of glasses is indispensable, and it is well to make the series large enough to include all the gradations which are to be found in commerce, or for which grinding tools are kept by the opticians. Such a series, in dioptrics, contains thirty-three numbers, ranging from 0 to 3 with a common interval of .25, from 3 to 6 with a common interval of .5, and from 6 to 20 with a common interval of 1. Each number is represented by thirty-two convex and thirty-two concave spherical glasses, and it is a practical necessity, for rapid work, to have these in pairs, making thirty-two pairs of convex and thirty-two pairs of concave spherical glasses. The numbers from .25 to 10 (twenty-two numbers) are also represented by convex and concave cylindrical glasses, and it is very convenient, though not so essential as in the case of the spherical glasses, to have these also in pairs. The trial-case of this com-

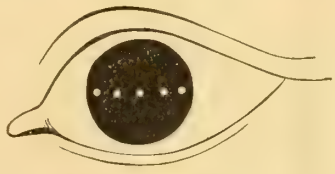


Fig. 2632.

position contains, therefore, $4 \times 32 = 128$ spherical, and $4 \times 22 = 88$ (or $2 \times 22 = 44$) cylindrical glasses—a total of two hundred and sixteen (or one hundred and seventy-two) glasses. A pair of plane glasses (No. 0), and a single convex and concave glass of the value of .125 ($\frac{1}{8}$ dioptric), for the purpose of dividing the somewhat too large intervals of .25 between the limits 0 and 1, raise the number of glasses to two hundred and twenty or one hundred and seventy-six. In addition to the spherical

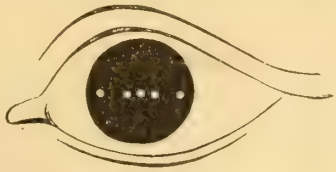


Fig. 2633.

and cylindrical glasses the trial-case should include a series of prisms, ranging from 1° to 12° or 16°, an unpolished glass, a few plane glasses of different colors, a stenopæic disk with a narrow slit, and a few diaphragms of thin metal with single and double perforations of dif-

ferent sizes.* With such a series of trial-glasses any case of binocular compound or mixed astigmatism may be provisionally corrected by a combination of two glasses for each eye. Much smaller series of glasses may be selected, in which dual combinations of the spherical glasses are entirely sufficient for the provisional correction of any case of simple hypermetropia or myopia, although somewhat less conveniently and with some loss of time. With a full series of cylindrical glasses, which, as a matter of economy, may be composed of concave glasses only, it is thus possible to correct any case of compound or mixed astigmatism in one eye by a combination of one

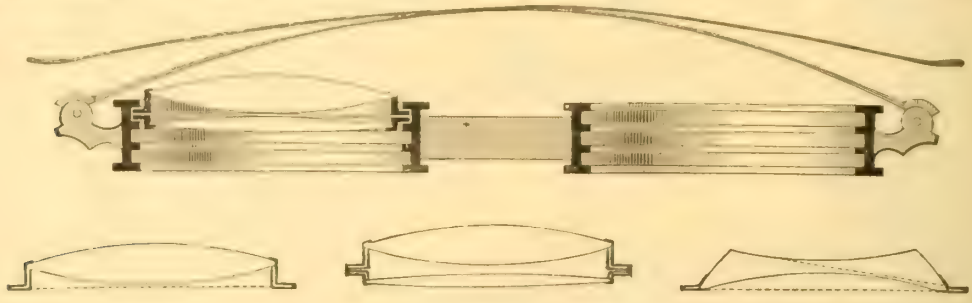


Fig. 2634.

cylindrical and two spherical glasses.† The glasses of the trial-case should be set in rings of "spun" brass, with very thin flanges like the wheels of a railway carriage, so that the flanges of any two glasses may be placed in contact, and fitted into a single groove in the trial spectacle-frame (Fig. 2634).[25] This frame should be provided with adjustments for holding the glasses, in a vertical position, at a suitable distance (13 mm.) in front of the vertex of the cornea, and also for accurately centering the glasses in front of the two eyes. It is also very convenient to have a rotary adjustment, by means of which the axis of the cylindrical glasses (also of the prisms and the stenopaeic disks) may be set at any required angle. Trial frames of fairly satisfactory construction are now furnished by most of the instrument-makers, although much is still to be desired on the score of lightness, simplicity, and compactness. Fig. 2635 shows one of the most complete forms.

By enlarging the series of test-letters through the addition of a few numbers, so as to extend its range to say 0.1 metre, the position of the near-point (p) may often be determined by direct observation. Oftener, however, we determine the position of p after having provisionally corrected the eye for distant vision, by means of glasses; for practical purposes it is generally sufficient to measure the distance (P_2) of the binocular near-point (p_2)‡ from the anterior nodal point of the eye.

We may also use the card of test-letters for the direct determination of the grade of myopia, by simply noting the greatest distance at which the letters corresponding to that distance are distinctly recognized. In the lower grades of myopia good measurements may often be made in this manner, but in the higher grades the convergence of the visual axes is ordinarily attended with some degree of accommodation, and the measurement is apt to be somewhat in excess of the actual myopia.

Optometers for the measurement of the refraction, and also of the range of accommodation, at some short distance, say, of one foot, have been made in a great variety of forms; they are, however, of much less value than might be expected, whether as regards saving of time in observation, or accuracy of results. The binocular optometer of Javal (see vol. i., p. 403) is by far the best, and is perhaps the only instrument of its class with which really good clinical work may be done.

Other subjective methods of dioptometry, in which the recognition and naming of test-letters or other similar objects is not required of the patient, turn upon the measurement of circles of confusion in the retinal image, on the appreciation of differences in the size of the retinal images in certain types of ametropia, on the mixing of colors in the retinal image through the overlapping of circles of confusion of different colors, and on the analysis of compound colors through the chromatic aberration of the eye.

A point of light, such as the flame of a small taper or gas-jet, viewed from a distance of, say, five metres, is seen by an emmetropic eye as a bright point, with some indication of bright rays, as in the familiar picture of a star (see vol. i., pp. 404 and 405). The same point is seen by a myopic eye, or by a hypermetropic eye in a state of accommodative relaxation, under the form of a bright spot (circle of confusion) of a greater or less diameter, determined by the grade of ametropia and by the size of the pupil. When the pupil is fully dilated by a mydriatic, the size of the circle of confusion is approximately proportionate to the degree of ametropia, so that a pretty exact measurement may be made by simply noting the distance at which two tapers must be placed, one from the other, in order to make the two circles of confusion touch each other. Thomson[26] has devised an apparatus (Fig. 2636) in which two small gas-jets are so arranged as to admit both of varying the distance between the two lights and of altering their direction to correspond to different ocular meridians; the degree of ametropia is read off directly from a scale which forms a part of the instrument. This method is both simple and practical, and it may be made to yield very excellent results in a large proportion of cases.

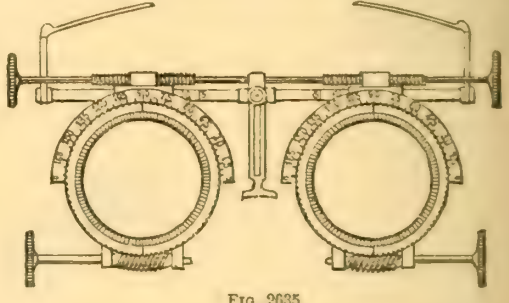


Fig. 2635.

* The trial-cases, as made up by the instrument-makers, invariably lack some of the glasses and accessories mentioned in the text; a trial-case should, therefore, be composed according to definite specifications, and space should be provided in the box for some additions.

† As an example of a limited series of trial-glasses, the following combination is suggested as sufficient for nearly all purposes: spherical glasses, convex and concave, in pairs, Nos. .25, .50, .75, 1, 1.25, 1.50, 1.75, 2, 2.25, 2.50, 2.75, 3, 6, 9, 12, 15, 18 = 4 + 17 = 68 glasses; cylindrical glasses, concave only, single, Nos. .25, .50, .75, 1, 1.25, 1.50, 1.75, 2, 2.25, 2.50, 2.75, 3, 3.50, 4, 4.50, 5, 5.50, 6, 7, 8, 9, 10 = 22 glasses; total, 68 + 22 = 90 glasses. To these should be added at least twelve prisms, ranging from 1° to 12°. See Trans. Am. Ophl. Soc., 1878.

‡ The binocular near-point (p_2) is the nearest point of distinct vision when the two eyes are made to converge upon a near object; the absolute near-point (p_0) is the nearest point of distinct vision with a single eye when its fellow is covered and assumes a position of convergence in excess of that which corresponds to the distance of the object. See Donders, On the Anomalies of Accommodation and Refraction of the Eye, chapter iii. New Sydenham Society: London, 1864.

64.
CXCII.

50.
CL.

40.
CXX.

32.
XCVI.

25.
LXXV.

20
LX.

16
XLVIII

12 5
XXXVIII.

10.
XXX.

8.
XXIV.

6.25
XIX.

5.
XV.

4.
XII.

By making the effective area of the pupil very small, as in looking through a pinhole pricked in a blackened card, the circles of confusion may be so reduced in size as to admit of tolerably distinct vision even in the higher grades of ametropia. If two pinholes are pricked in the card, at a distance of, say, four millimetres from each other, a pretty distinct image of a test-object will be formed by the rays passing through each of the pinholes, but the two bundles of rays will fall upon different parts of the retina whenever the eye is focussed for any distance other than that of the object. This experiment, first described by Scheiner,[27] has been utilized in the optometers of Porterfield,[28] Young,[29] Stampfer, and others, and has been further developed in a method for the clinical investigation of ametropia by Thomson[30] (see vol. i., p. 404).

The doubling of the retinal image of a test-object through the deflection produced by a thin prism the edge of which bisects the pupil, as in the ophthalmometer of Javal and Schiötz, has been utilized by Culbertson[31] as the basis of a method of subjective dioptometry. The test-object is a white disk of about the size of No. 60

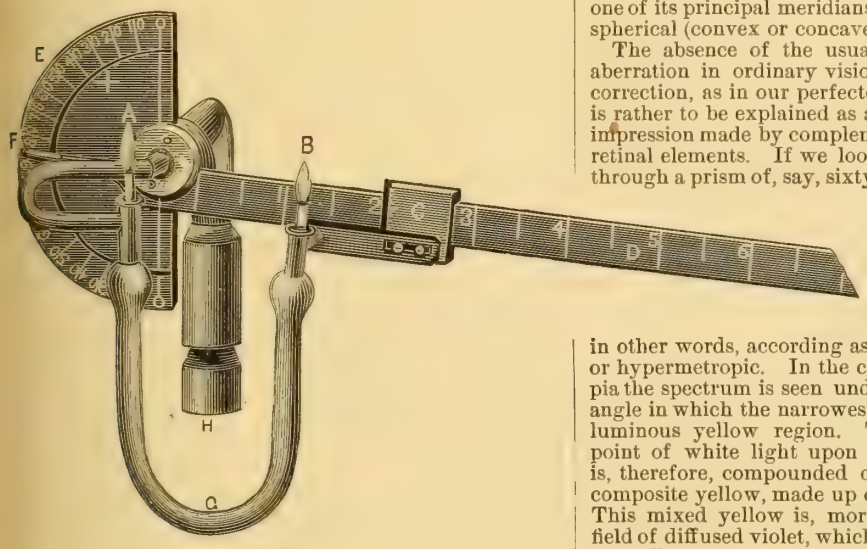


FIG. 2636.

(metric series) of Snellen's test-letters, placed at such a distance (five metres, more or less) that an emmetropic eye sees the two images of the disk exactly in contact at their margins. Inasmuch as in typical (axial) hypermetropia the retinal images are smaller, and in (axial) myopia larger, than in emmetropia, the two images are seen separated by a certain interval when viewed by a hypermetropic eye, and more or less overlapped when viewed by a myopic eye. When the ametropia is corrected by a neutralizing (convex or concave) glass, placed at the anterior focus of the eye (about thirteen millimetres in front of the cornea), these differences in the size of the image disappear* and the two disks appear exactly to touch each other. To detect astigmatism the eye is first corrected for contact of the two images, in, say, the horizontal meridian, after which the prism, which covers one half of the pupil, is so turned as to make the line connecting the centres of the two images correspond in direction to other ocular meridians in succession. The difference in the values of the two spherical glasses which bring the images exactly into contact in the meridians of greatest and of least refraction is an approximate measure of the degree of astigmatism.

*H. Knapp first called attention to the fact that "spectacles worn half an inch before the eye do not alter the position of the first cardinal points, nor the focal lengths of the eye." Transactions of the American Ophthalmological Society, 1869.

When a colored test-object, in a field of a contrasting color, is viewed by an eye adjusted for some distance other than that of the object, the circles of confusion, representing parts of the object and of the field adjacent to the line of demarcation of the two colors, overlap in the retinal image and form the combination-color proper to the mixture. The experiment succeeds best when the test-object and the contrasting field are printed in transparent colors and viewed by transmitted light. A sheet of ground glass coated with varnish colored blue by ultramarine, with a small central area similarly painted with carmine, makes an excellent test-object for this purpose; the two transparent colors should be separated by a thin black line (see Plate XXIV., Fig. I.). When the test-object is hung in a window, and is viewed from the opposite side of the room, the central (red) spot is seen in its actual color when the eye is accurately focussed for its distance, but in a combination (purple) tint whenever the eye is focussed for some other distance. The difference between the carmine-red and the combination-purple is especially striking in astigmatism, when the test-object is made up of radiating lines of carmine, in the blue field (see Plate XXIV., Fig. II.),[32] and the eye is corrected for one of its principal meridians by means of the appropriate spherical (convex or concave) glass.

The absence of the usual phenomena of chromatic aberration in ordinary vision is not due to any optical correction, as in our perfected dioptric instruments, but is rather to be explained as an effect of the simultaneous impression made by complementary colors upon the same retinal elements. If we look at a distant point of light, through a prism of, say, sixty degrees angle, the spectrum will be seen under the form of a triangle, whose apex will be either in the red or in the violet, according as "the focus of the eye is adapted to collect the red or the blue rays to a point;"[33] in other words, according as the eye is slightly myopic or hypermetropic. In the condition of perfect emmetropia the spectrum is seen under the form of a double triangle in which the narrowest part lies in the very strongly luminous yellow region. The impression made by a point of white light upon any single cone of the retina is, therefore, compounded of the spectral yellow and a composite yellow, made up of the red and the green rays. This mixed yellow is, moreover, superimposed upon a field of diffused violet, which must tend further to modify the yellow so as to approximate it more or less closely to white.

The chromatic aberration of the eye reveals itself very clearly in looking at a point of light of which all but the blue and red rays have been extinguished, by the passage of the beam through a sheet of cobalt-blue glass.[34] Looking through such a glass an emmetropic eye, focussed for the distance of the light, sees it of a nearly uniform purplish-blue tint, with an inconspicuous halo of a clearer blue; a myopic eye sees the same light red, with a blue halo; and a hypermetropic eye, uncorrected by accommodation, sees it blue, with a red halo (see Plate XXIV., Fig. III.). To measure the grade of ametropia it is only necessary to find the spherical (concave or convex) glass which, added to the cobalt glass, gives the picture of a blue light slightly fringed with a clearer blue.

An emmetrope, looking at a red and a green light, like those carried by vessels and used also as railway signals, sees the two lights of the same magnitude; a myope sees the green light as a circle of confusion which is always larger than the image of the red light; and a hypermetrope, with imperfect accommodation, sees the red light larger than the green. When the vision is corrected for the distance of the lights they are seen in their normal relation of equality in size.[35]

Ophthalmostatometry—from ὀφθαλμός, eye, and στα-, root of ἵστημι, to stand—is the measurement of the position of the eyes. As the two eyes, working under normal conditions, perform essentially the function of a sin-

gle complex organ, the most important measurements are those which have to do with the two eyes together in respect of their mutual distance and the relative direction of the visual axes.

The distance between the two eyes may be roughly measured by looking the patient in the face and letting him direct his gaze alternately upon the two eyes of the observer, who, in turn, reads off the position of the fixing eye with his fixed eye upon a rule, graduated in millimetres, which may be held in the hand or mounted upon a spectacle frame. The right or left corneal margins, or the right or left margins or the centres of the pupils, may be taken as fixed points whose mutual distance is an approximate measure of the true interocular distance. The inaccuracy of this, as of all objective methods of measuring the interocular distance, lies in the fact that the visual axis does not exactly coincide with the geometrical axis of the eye, but in fact cuts the cornea, as a rule, a little to the inner (nasal) side of its vertex. The angle which the visual axis makes with the axis of the cornea (angle α of Donders)[36] averages about five degrees in the emmetropic eye; it is somewhat greater in hypermetropic and less in myopic eyes, and in very high grades of myopia it may even be negative, so that the visual axis may cut the cornea at, or a little to the outer side of, its vertex. Objective measurements of the interocular distance are, therefore, ordinarily a little too large, though sufficiently accurate for almost all practical purposes.

If we place a diaphragm, with a central perforation of, say, one millimetre in diameter, in each of the clips of a trial spectacle-frame, and adjust the distance of each from the median line of the nose so that the image of a distant vertical line shall be seen, by the patient, bisecting the small circular field as defined by the margins of the perforation, the distance between the centres of the two perforations will be the true measure of the distance of the two (parallel) visual axes from each other.[37]

The "chiastometer"—from *χιαστός*, crossed—of Landolt, is a long box, with two sight-holes at one end, and a diaphragm placed midway between the farther end of the box and the plane of the centres of rotation of the two eyes of the patient when his eyes are applied closely to the two sight-holes. In this diaphragm is a narrow vertical slit, and at the farther end of the box are two sliding covers, each with a small perforation or a narrow vertical slit. The patient, looking into the box, directs each eye in turn toward the slit in the central diaphragm, through which the eye receives light whenever the sliding cover at the opposite corner of the box is so adjusted that its perforation, the central slit, and the centre of rotation of the eyeball are all in the same line. The distance between the two openings in the sliding covers is equal to the distance between the centres of rotation of the two eyes.

To measure any deviation of the optic axes from parallelism, when the patient fixes his gaze upon a distant object, it is only necessary to hold a lighted candle in front of the deviated eye, say, at a distance of one foot, and to move the candle in different directions until its image, as seen reflected in the cornea, occupies a position central to the pupil when viewed from a station just behind the light. The angle at which the light must be held to one side of a line drawn from the centre of the observed eye to the (very distant) point fixed by the other eye is the measure of the angular displacement of the deviated eye; it may be conveniently measured upon the arc of a perimeter, the eye whose deviation is to be measured being at the centre of the arc (Landolt).

Ophthalmotropometry—from *ὀφθαλμός*, eye, and *τροπή*, turning—is the measurement of the movement of the eyeballs. The most important, from a clinical standpoint, are the measurements of the mutual relations of the recti interni and recti externi muscles, and of defects in motility dependent on muscular paresis.

Closely related to the near-point (p) of accommodation is the near-point for convergence; and as we express the distance of the former from the anterior nodal point in terms of dioptries, so we measure the distance of the latter from the centres of rotation of the two eyes, in the equivalent metre-angles.[38] We may, therefore, conveniently employ the symbol p^c for the near-point of convergence, and P^c for the common distance of p^c from the centres of rotation of the eyes; r^c and R^c may be similarly used to designate the far point for convergence and the distance of this far-point from the two centres of rotation.[39]

In insufficiency of the recti interni, not amounting to strabismus divergens, the phenomenon of double vision (see Diplopia) does not ordinarily manifest itself so long as it is possible to maintain the fusion of the two retinal images through the forced exercise of the convergence; if, however, we displace one of the retinal images upward or downward, by means of a prism, the insufficiency of the interni immediately reveals itself by a crossing of the images, which then assume an oblique direction, one to the other, instead of the vertical direction proper to the action of the prism. The measure of the insufficiency is the prism, with edge turned horizontally outward, which is required to convert the oblique into a vertical diplopia. This test may be applied both at a long range and at shorter distances; it reveals the state of the convergence as related to the degree of accommodation which is brought into play at the particular distance. Any insufficiency that may be revealed by this test after the correction of the refraction by neutralizing glasses is to be regarded as the actual insufficiency of the recti interni.

Insufficiency of the recti externi, or preponderance of the recti interni, is tested, *mutatis mutandis*, in the same manner as insufficiency of the interni.

In paresis of one of the recti interni the near-point for convergence (p^c) recedes from the eyes, the degree of recession varying from zero when the eyes are turned to the unaffected side, to a maximum when the eyes are turned in the opposite direction. The measurement of the position of p^c should be made when the patient looks directly forward; a metre-stick, divided into aliquot parts, may be used, and the distance noted at which a thin rule, held vertically against the metre-stick, first appears doubled on approaching the eyes. The denominator of the fraction of a metre thus measured, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc., is the measure of the maximum convergence in metre-angles. In paresis of one of the recti externi the far-point for convergence (r^c) approaches the eyes; the measurement of its position and of the minimum convergence in metre-angles is similarly obtained by means of the metre-stick and rule.

Binocular vision, conditioned on the simultaneous perception and comparison of the two retinal images of the object upon which the two eyes are directed, is most easily tested by means of the stereoscope. Rejecting all representations of objects in which solid forms are suggested by perspective, as is almost always the case with photographs of objects in nature, we make use of diagrams of the simplest possible construction; a few examples of these are shown in the figures on page 357.[40] Viewed in the stereoscope Fig. 2637 is seen as two disks, the one vertically above the other, but lying in two different planes at different distances from the observer; the upper disk, which is perceived through the combination of two component images under a lesser degree of convergence of the visual axes, appears to be the more distant, but, as the retinal images are all of the same size the upper disk appears also to be larger than the lower disk; if we invert the slide in the stereoscope the upper disk will appear to be nearer and smaller than the lower disk. Fig. 2638 shows a circle and an ellipse, which may be considered as two different perspective views of one and the same larger ellipse; when the two images are combined by the stereoscope a horizontally elongated ellipse is perceived, and this ellipse is seen rotated about its vertical diameter as an axis; if we invert the slide the ellipse will be seen rotated in the opposite direction. In Fig. 2639 the ellipse is seen to tip backward or forward, according as the slide is placed in the stereoscope in the

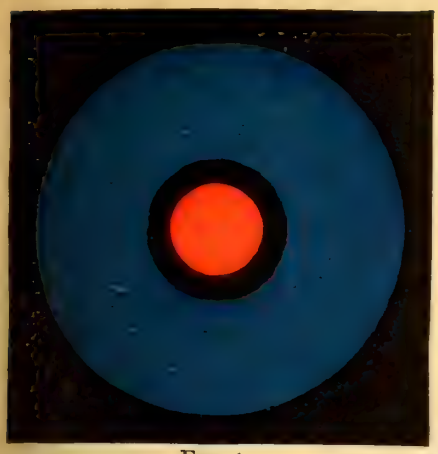


FIG. 1.

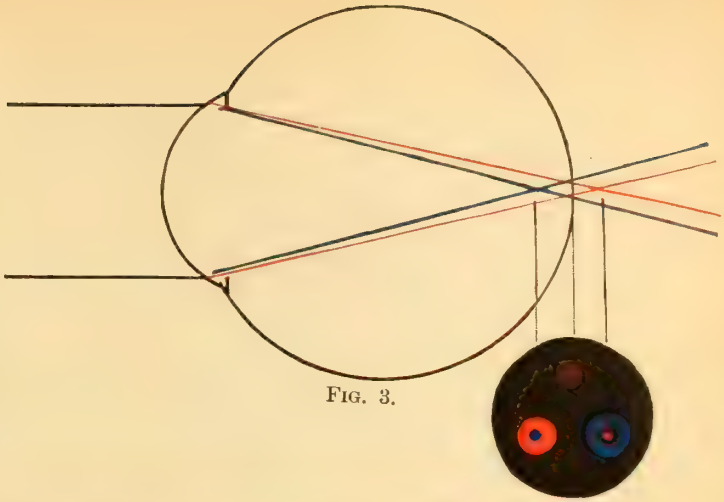


FIG. 3.

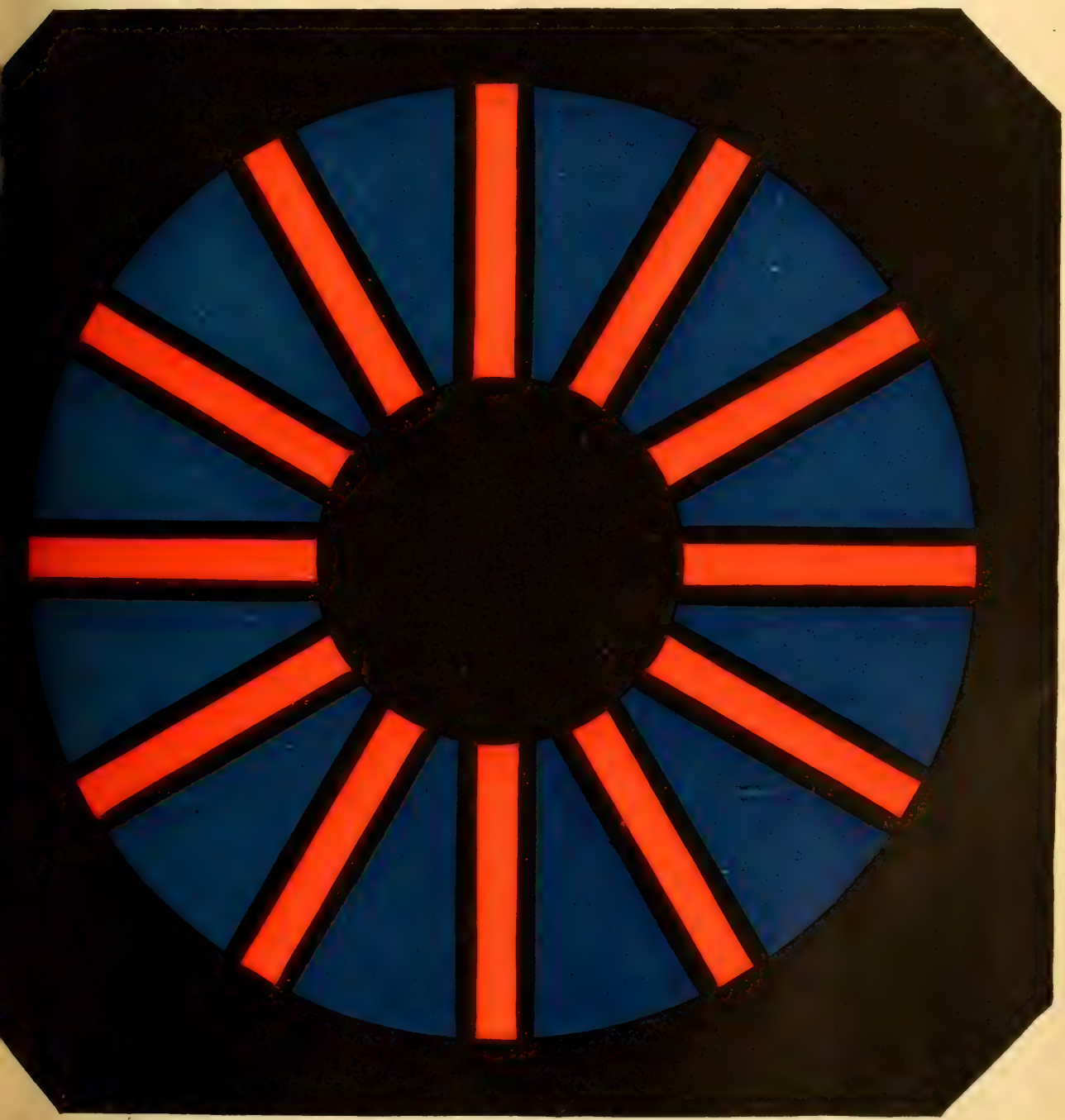


FIG. 2.

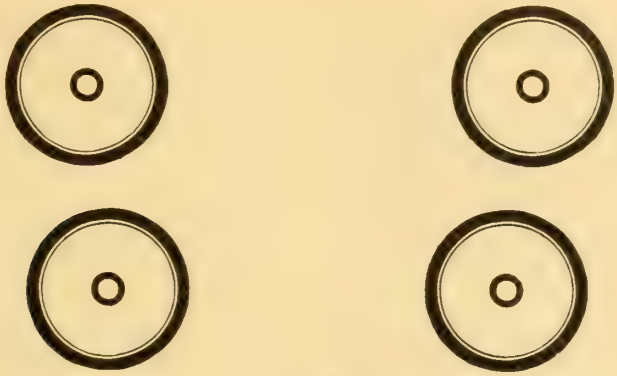


Fig. 2637.

Fig. 2638.

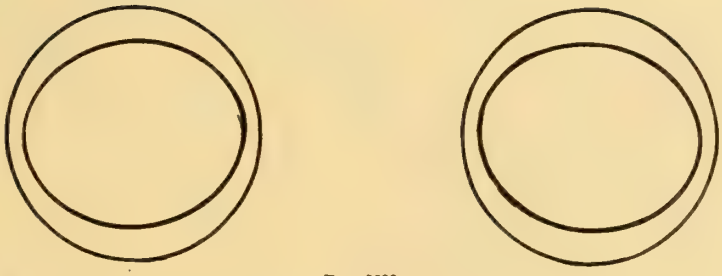


Fig. 2639.

Fig. 2640.

position shown in the plate, or inverted. Fig. 2640 shows a combination of a ring with a white centre and a black disk of the same diameter; the effect is that of a mirror, or rather of a shining surface polished with plumbago. When these slides are viewed in the usual way in a stereoscope the binocular perception is the result in part of the simultaneous perception of two component images formed upon slightly non-correspondent parts of the two retinæ, and in part of changes in the convergence of the visual axes in viewing different parts of the picture; the latter element is eliminated when the slide is illuminated for but an instant by means of an electric spark. *John Green.*

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ORANGES, SWEET AND BITTER. The rind of these delicious fruits, and the essential oils obtained from them, as well as those of the flowers, are employed in pharmacy and medicine as flavors, without having much of any therapeutic activity. It is questionable whether the trees producing the two kinds are really specifically distinct from each other; but as they do not appear to run together very closely, and are very well separated as market products, it is usual, following Risso, to grant specific distinction.

1. *Citrus Aurantium* Risso, the Sweet Orange, is a familiar plant in all warm countries. It is a small, rather slow-growing tree, with hard wood, an upright, much-branched trunk, bearing a well-rounded, rather close head. Leaves numerous, thick, evergreen, smooth and shining, oval; the blade articulated to the distinctly winged petiole. Flowers axillary, perfect, regular, large, fragrant, white; calyx short; petals five, long, fleshy, spreading; stamens numerous; ovary free, eight- or more celled, several ovules in each cell. The leaves and petals are fragrant, and show by transmitted light pellucid spots indicating the large oil reservoirs in their parenchyme. The fruit is the well-known Orange, and needs no description (see Fig. 2641).

C. vulgaris Risso, the source of the Bitter or Seville Orange, is a smaller tree, with a closer head, larger, more fragrant flowers, and a rougher, darker, sour, and bitter fruit. This plant is also rather more spiny than the other, and propagates more true from seed. Both the above plants have developed numerous varieties, especially the former, of which nearly fifty have been described, and which must be propagated by grafting, as those of the apple and other fruits are.

The home of the Orange is in Asia, either Northern India or China, but its wild state is scarcely known, so

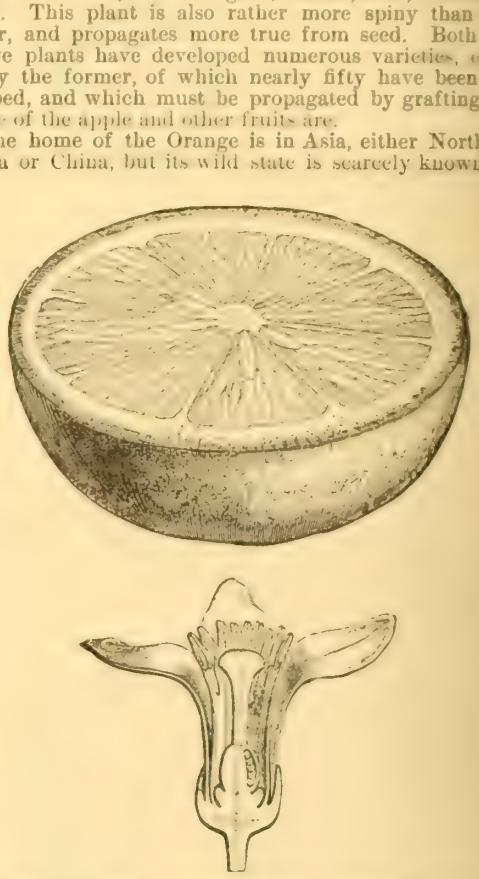


Fig. 2641.—Sweet Orange Flower and Half of Fruit. (Baillon.)

long and completely has it been domesticated. It was introduced into Europe in the fifteenth century, and is now cultivated in most warm countries. Those of our market come largely from Messina and Valencia, and in rapidly increasing quantities from Florida. California and the West Indies also supply a considerable number.

The officinal products are:

Orange Flowers (*Aurantii Flores*, U. S. Ph.).—The partly expanded fresh flowers of either species. Also the same flowers preserved in half their weight of salt. It is needless to say that these flowers in either of the above conditions are not to be found, in Northern shops at least. Dried orange flowers are to be had, imported from Europe, and good in proportion to their freshness. They are only used for their perfume, or, "when fresh," as a source of the distilled oil and water (*Aqua Aurantii*, U. S. Ph.; *Oleum Aurantii Florum*, U. S. Ph., Neroli).

Orange Peel.—Of this the two varieties are always kept distinct; Bitter Orange Peel (*Aurantii Amari Cortex*, U. S. Ph.; *Aurantii Cortex*, Br.), from *C. vulgaris*, has a reddish or brownish-green color, a very bitter and aromatic taste. Sweet Orange Peel (*Aurantii Dulcis Cortex*) is of

an orange-yellow color, sweeter, less fragrant, and less bitter. Both should be peeled with a knife, so as to get but little more than the outer glandular layer of the rind. They come in long, curling ribbons, about half an inch wide. From the first, a Fluid Extract and Tincture (*Extractum Aurantii Amari Fluidum*, ½; *Tinctura Aurantii Amari*, U. S. Ph., ⅛) are made; from the second, a syrup and another tincture (*Syrupus Aurantii*, $\frac{8}{100}$; *Tinctura Aurantii Dulcis*, U. S. Ph., ⅛), all used for flavoring. Of the unofficinal products there are many, among them the little unripe fruits (orange berries, *Fructus Aurantii Immaturi*, Ph. G., "*petits Grains*"), the oil of the leaves, curiously called *Essence des petit Grains*, etc. The flowers and the oils of the sweet and bitter orange are also, nominally at least, offered as separate products, of which the latter are usually finer and considerably more expensive.

Composition.—The flowers contain about half of one per cent.—those of the bitter more than the sweet—of the

Fig. 2642.—Bitter Orange Tree; Flowering Branch. (Baillon.)

essential oil above mentioned, and usually called Neroli, or less properly, "Oil of Neroli." It is a brownish liquid, having a very agreeable odor. The Peel also contains the *Oil of the Peel*, differing in flavor from the above, and further, that of the bitter differing slightly from the sweet. Both varieties are officinal, without distinction, as *Oleum Aurantii Cortex*. These two oils (of the peel) are obtained by mechanical processes similar to those used for separating the oils of Lemon and Bergamot (*q. v.*); that of the flowers is distilled. The Peel contains also a pleasantly bitter, crystalline, neutral principle, *hesperidin*, common to the peels of the other fruits of the genus.

Action and Uses.—This paragraph is almost unnecessary in view of the details above given. None of the above products is given, excepting as an adjuvant or flavor. The oil is stomachic, stimulant; the bitter probably tonic. Orange pulp or juice is a pleasantly refrigerant article of sick diet. It contains sugar and a little *citric* acid.

Allied Plants.—The numerous varieties of *Citrus* are usually divided among the following species, after Risso:

Citrus vulgaris Risso, *C. Aurantium* Risso, Bitter and Sweet Oranges.

C. Bergamia Risso, Bergamottes.

C. Limonum Risso, Lemons and Limes.

C. Limetta Risso, "*Limettes*," cultivated like Bergamottes for the oil obtained from the rinds.

C. Medica Risso, Citrons, and, finally,

C. Decumana Linn., the Shaddocks, whose enormous and sweetish fruits are eaten like oranges. All the above species are supposed to have had their origin in Northern India. *Ægle marmelos* Corr., Bael., is distinguished from *Citrus* by its dry, non-edible fruit, and its three-parted leaves; the fruit is used as a medicine in India, and now and then seen as a rarity in the shops of this country. The order *Rutaceæ*, including *Aurantiæ* as a subdivision, is a large one, distributed over the warmer parts of both hemispheres. Its species are generally fragrant. The following are of medical interest: *Ruta graveolens* Linn., Rue; *Dictamnus Albus* Linn., Fraxinella; *Cusparia trifoliata* Engl., Angostura Bark; *Pilocarpus pennatifolius* Lemaire, etc.; *Barosma*, several species of which furnish Buchu; *Xanthoxylum*, etc.

Allied Drugs.—The Citrus species form a very natural therapeutic, or rather dietetic group of themselves. The action of their oils resembles that of the less irritating essential oils in general (see Anise), that of their bitter principle is probably like that of the milder bitters; the sugar and acid of their fruits make them a most refreshing addition to the table, either of the well or of the sick. Sour varieties of all the species are used in the manufacture of citric acid, while the bitter ones are made into jams, etc., with sugar. *W. P. Bolles.*

ORBIT, DISEASES AND INJURIES OF THE.

These affections have great interest and importance, not only with reference to the preservation of sight, but on account of the close topical and vascular connection of the contents of this cavity with other parts, particularly the brain, and the difficult and serious problems in diagnosis and prognosis which they frequently offer. They are, comparatively, not very common. The one most frequently met with is

Orbital Cellulitis.—This is not generally difficult to recognize. It is usually an acute disease, and often of a violent inflammatory character. Pain, which is a prominent symptom, is in proportion to the degree of swelling and consequent pressure, and when this is excessive is very intense. It is referred to the ball and orbit and to the parts of the face to which the ramifications of the ophthalmic branch of the fifth nerve are distributed, and is always increased by the slightest backward pressure of the globe. The conjunctiva is congested and soon becomes chemosed, and the lids are swollen and œdematous and have an erysipelatous appearance.

The most striking symptom is the exophthalmus, which is decided, even in slight cases and in the early stages. The diplopia resulting from displacement of the eyeball is sometimes among the first symptoms, and may even occur before the exophthalmus attracts attention. In severe cases, particularly if an abscess is formed, the protrusion of the ball may be so great that the lids can no longer cover the cornea. The movements of the eye are, of course, restricted and painful, or it may be completely fixed in its unnatural position.

More or less constitutional disturbance is to be expected, and the formation of pus is usually announced by well-marked rigors. Suppuration is the rule, but a few cases end in resolution, a result said to be much more frequent in children than in adults. This form of the disease is sometimes called "œdematous cellulitis." When an abscess is evacuated spontaneously, the pus escapes through the skin of the lids, near the superior or inferior orbital margin, or sometimes behind the lids, through the palpebro-ocular fold of the conjunctiva. In the latter case the disease is sometimes mistaken for purulent con-

junctivitis. In rare cases orbital cellulitis assumes a chronic form, and ends by the escape of pus only after the lapse of months or years. There may be little or no pain, and no decided symptom but the exophthalmus. There is likely to be periostitis or caries in such cases.

Etiology.—Idiopathic cellulitis is so rare that Pagenstecher is disposed to deny its occurrence, and to maintain that cases described as such have been due to the extension of inflammation from a focus which had escaped the attention of the observer (*Arch. of Oph.*, vol. xiii.). Primary cellulitis in healthy adults must be considered, to say the least, a very unusual affection, but its occasional occurrence in delicate children is generally admitted. Perhaps the most frequent causes are direct injuries of the orbital tissue and extension of local inflammation from neighboring parts. Operations upon the appendages of the eye, or even upon the ball itself, are sometimes followed by this complication. Bull (*Am. Jour. Med. Sci.*, July, 1878) reports a case following excision of a prolapsed iris, and one after iridectomy for glaucoma. A number of cases have been recorded in which an inflammation of the maxillary antrum, excited by carious teeth, or by an injury to the alveolar processes in attempts to extract them, has extended to the orbit. Phlegmonous erysipelas of the face has extended to the orbital tissue in a number of cases. Finally, orbital abscess may be the result of a metastatic process in puerperal fever, phlebitis, typhus, carbuncle, etc. While thrombosis of the orbital vein necessarily occurs in orbital phlegmon, and may extend to the cavernous sinus, orbital cellulitis may have its origin in suppurative phlebitis of the ophthalmic vein. It is well known that suppuration may be communicated to the ophthalmic vein and cavernous sinus from abscesses of the lids or lips, operations about the face, the extraction of teeth, and especially from facial erysipelas. In a fatal case of suppurative phlebitis of the ophthalmic vein and cavernous sinus, following malignant abscess of the tonsil, Professor Panas (*Arch. d'Ophthal.*, t. v.) thinks the disease was communicated through numerous anastomoses which have been shown to exist between these vessels and the spheno-palatine vein. Cases of orbital cellulitis following diphtheria are reported by Knapp and Heyl (Nettleship, "St. Thomas's Hospital Reports," vol. xi.). Knapp (*Arch. of Oph.*, xiii.) has shown that orbital cellulitis is present in all cases in which blindness results from facial erysipelas.

Diagnosis.—The conditions with which orbital cellulitis is most likely to be confounded are periostitis of the orbital walls and new growths in the cavity. In periostitis the progress of the disease is usually less rapid, and the pain, though perhaps less severe, is an earlier symptom and may even be the first. Except in cases in which only the deeper parts of the orbit are affected, a tender spot can frequently be detected by passing the finger as far back as possible and pressing against the wall. While in cellulitis the eye is usually protruded directly forward, and its motions are limited equally in all directions, it is likely to be given a special direction by the more localized swelling of periostitis. These two lesions may, however, sometimes appear together, the inflammation extending from the periosteum to the orbital cushion. The acute course of cellulitis will usually distinguish it from orbital growths. The eye is rarely protruded directly forward by a tumor, and the latter may often be felt with the finger. The diagnosis is, however, sometimes extremely difficult, and may prove a stumbling-block to the most skilful and careful observer. This is well illustrated by a case that occurred some years ago in the experience of no less an authority than Professor Jaeger. He was sent by the emperor to Milan to examine Marshal Radetzky, who had been suffering for three months with a high degree of exophthalmus and its accompanying symptoms. He reported that the patient, who declined any operative interference, was affected with scirrhus of the soft parts of the orbit, which would probably soon end his life. Not long afterward, under homœopathic treatment, there was a copious discharge of pus, and the eye returned to its normal position (*Annales d'Oculist.*, xxiii., p. 14).

Prognosis.—Though a large proportion of cases of orbital cellulitis recover without serious injury to the eye, the disease is a dangerous one and places not only sight but sometimes life in peril. The most frequent causes of loss of sight are injury to the optic nerve from pressure and stretching, and interference with the circulation in the central vessels of the retina. The tense chemosis may cause the cornea to slough, or panophthalmitis may result from interference with the circulation of the choroid or direct extension of the inflammation to that membrane. The movements of the ball are sometimes permanently impeded by cicatricial contractions or atrophy of the external muscles, or their paralysis from injury to the nerves. Life is threatened by direct extension of inflammation to the meninges, through the sphenoidal fissure or optic foramen, or by thrombosis of the ophthalmic vein. According to Berlin (Graefe-Saemisch, vol. vi.), fatal pyæmia may result without extension of thrombosis beyond the orbit, or the thrombosis may extend to the brain sinuses. He thinks that the latter condition may be diagnosticated positively if exophthalmus occurs suddenly in the other eye. Exophthalmus frequently results from venous obstruction only, with little or no inflammation of the orbital tissue, and is a constant and important symptom of phlebitis of the cavernous sinus.

Treatment will necessarily vary with the violence of the local inflammation and the general condition of the patient. In traumatic cases, and others occurring in persons in fair health, leeches may be applied to the temple in the early stage of the affection before suppuration has commenced. Even this kind of depletion, however, is to be condemned in the large proportion of cases in which the inflammation of the orbital tissue is a complication of some exhausting disease. Hot stupes will promote resolution while there is hope of that termination; but warm fomentations or poultices should be applied when it is desirable to encourage suppuration. Extract of belladonna applied to the temples and brow is useful in relieving pain, but most cases will require the liberal exhibition of anodynes. When suppuration is evident, there is no question about the propriety and urgency of free incision, and when it is doubtful it is often prudent to make an exploratory puncture. When great swelling inflicts intense pain and threatens the integrity of the eyeball and optic nerve, deep and free incisions should be made without waiting for indications of suppuration, and with a view to relieving the tension of the parts. A narrow, straight bistoury or a long Graefe cataract-knife is entered near the upper or lower margin of the orbit, and its point kept near the roof or floor, while it is passed toward the apex of the orbit. It is well to keep the wound open by a tent of carbolized or borated lint.

TENONITIS.—The capsule of Tenon is a fibrous envelope of the ball, derived from the dural sheath of the optic nerve, and lined by a serous membrane which, according to some authorities, is continuous with the arachnoid. The eyeball moves in this envelope like the head of a bone in its articular capsule. The recti muscles pass through this capsule at the equator of the ball, where it is intimately connected with their sheaths, and in the neighborhood of the corneal margin it is merged in the conjunctiva and subconjunctival tissue. While it forms a barrier to the extension within the eye of inflammatory processes when they commence in the orbital tissue, its direct connection, by means of the anterior ciliary vessels with the intra-ocular circulation makes this danger greater when the capsule itself is inflamed. On the other hand, it probably rarely entirely escapes participation in very acute and intense intra-ocular inflammation, and is the cause of the protrusion of the ball in panophthalmitis. In enucleation in such cases the extensive and firm adhesions of the capsule and the muscles and connective tissue about the ball often considerably complicate the operation. Tenonitis is said to occur occasionally after facial erysipelas or as a rheumatic affection, but is usually the result of extension of inflammation from the ball, or of direct injury. It has sometimes followed operations, especially those upon the external muscles. I have met with one case after

simple division of a muscle for strabismus, which recovered in a few days without injury to the eye; and one after the advancement of the internal rectus, which ended in disorganization of the ball.

The *symptoms* are conjunctival and subconjunctival congestion, sometimes with chemosis, moderate exophthalmus, restriction of the movements of the ball, and pain, greatly increased by pressing the eye backward. The lids are less affected than in cellulitis, and if pus forms it escapes on the surface of the ball.

Treatment will, of course, depend upon the cause and the intensity of the inflammation. Rheumatic cases require hot stupes, cotton compresses, anodyne applications, and the appropriate internal medication. In the early stages of traumatic tenonitis leeching at the temple, the local application of ice, and calomel internally may be needed.

Periostitis of the orbital walls is sometimes difficult to distinguish from cellulitis, and indeed the two conditions may exist together, or phlegmonous inflammation of the orbital connective tissue may originate in periostitis. The usual seat of periostitis of the orbit is near the margin, where it can be detected by pressure with the finger. The exophthalmus is not directly forward as in uncomplicated cellulitis, and the movements of the ball are limited more in the direction of the seat of the disease than in other directions. When the disease is at the apex, paralysis of some of the muscles of the ball is likely to ensue from involvement of the nerves at their entrance to the orbit. Periostitis usually, though not invariably, ends in suppuration. Sometimes there are more or less permanent localized thickening of the periosteum and consolidation of the neighboring tissue, which closely simulate a tumor. I have met with several such cases. In one there was a distinctly localized hard swelling in the upper inner wall of the orbit, extending as far back as the finger could reach. An exploratory incision was made, and when the finger was introduced into the wound it was found that the swelling was much less clearly defined than it had appeared to be—in fact, that it was merely a localized engorgement of the periosteum and neighboring orbital tissue. The part was freely scarified and the wound was kept open with a tent. The case soon ended in complete recovery without suppuration. In another case there was such a decided resemblance to a tumor in the region of the lachrymal gland that extirpation had been advised by two experienced surgeons. As the patient was known to have been under treatment some months previously with an aggravated attack of syphilitic pharyngitis, periostitis was diagnosticated, and a rapid cure followed the administration of heroic doses of iodide of potash.

Prognosis.—A large proportion of cases end favorably. The bone may become involved in the disease. In a few cases death has resulted from direct extension of inflammation from the periosteum to the meninges of the brain, or the escape of pus into the intra-cranial cavity. The danger is, of course, much greater when the deeper parts of the orbit are affected. In the chronic form the progress of the disease is very slow, sometimes extending over months, or even years.

The *cause* may be traumatic or rheumatic, or extension of inflammation from neighboring cavities, but it is most frequently syphilitic. The local *treatment* is the same as in cellulitis, and where suppuration is suspected or where excessive swelling endangers the eye or brain, early and free incision should not be neglected. Iodides and tonics are generally needed.

Caries and Necrosis of the orbital walls are usually the result of periostitis, though, in exceptional cases, the disease may commence as ostitis, and the periosteum be secondarily affected. The seat of the disease is, fortunately, most frequently near the margin of the orbit, where the danger of injury to the eye or extension to the brain is much less than when the deeper parts of the orbital cavity are involved. The adherent cicatrix of the skin, however, which invariably forms, is likely to cause serious deformity of the lids by its excessive contraction. This cannot be prevented, but must be remedied by operation, as best it may, after the affection of the bone has run its course. Abscesses should be promptly evacuated and a free opening maintained. When they discharge spontaneously the resulting sinuses will frequently need to be enlarged by the use of laminaria- or sponge-tents. The cavity should be frequently syringed with antiseptic solutions. The danger of reckless probing should be borne in mind, and no forcible attempts to remove sequestra should be made. Acute cases, which are often mistaken for erysipelas of the lids and face, may need local treatment. Iodide of potash is always in order, and should be given in large doses if syphilis is suspected. Many patients require a long course of treatment by quinine and iron and cod-liver oil, and careful attention to diet and hygiene.

Hæmorrhage in the Orbit is extremely rare from other than traumatic causes. It has occasionally occurred in scorbutic subjects, in sudden suppression of the menses and from violent coughing or muscular straining. Permanent hæmatomata have been formed by repeated hæmorrhages.

When hæmorrhage occurs in the orbit after serious injuries of the head, it is an almost certain symptom of fracture of the walls of the cavity; though intra-cranial hæmorrhage may find its way into the orbit without fracture. In a few cases of injuries bleeding has resulted from rupture of vessels within the orbit. The symptoms are exophthalmus and ecchymosis of the lids and conjunctiva. The ophthalmoscopic appearances are those resulting from sudden pressure.

In a case reported by Pagenstecher, in which a careful ophthalmoscopic examination was made fifteen minutes after the occurrence of the accident, the following condition was noted: "The retina was shining white, like porcelain, completely hiding the underlying choroid. The white discoloration was most marked in the neighborhood of the optic disk and the macula lutea. The peripheric portions of the retina were still transparent. The blood-vessels were narrow, arteries and veins being equal in size; the latter, however, darker in color." In a few days the vessels refilled, and the opacity of the retina, in great part, disappeared (*Arch. of Oph.*, vol. xiii.).

Treatment.—Iced-water or pounded ice should be applied while there is probability of further hæmorrhage, and afterward absorption may be hastened by a compressive bandage.

Emphysema of the orbit is still more rare than hæmorrhage. The symptoms are exophthalmus, and the characteristic crepitation on pressure upon the puffy lids. The *causes* are rupture of the lachrymal sac, or communication between the orbit and the frontal sinuses, ethmoidal cells, or nasal cavity. This communication with neighboring air-spaces is generally traumatic, but may be the result of ulceration. Rampoldi reports a case in which the emphysema developed, without injury, from chronic coryza. Exophthalmus, with diplopia, appeared whenever the patient sneezed or coughed, until he learned to prevent it by supporting the eye with his hand. The story is told of a convict who produced exophthalmus by introducing a pin at the root of a molar tooth and forcing in air from the mouth; and malingerers are said to have produced the same result by making a puncture beneath the eyeball and blowing in air through a tube. French jockeys have been accused of resorting to the latter expedient to give a youthful appearance to old horses with sunken eyeballs. No *treatment* is likely to be of much use. The patient should be cautioned against blowing his nose and encouraged to wait for the rent to close.

Exophthalmic Goitre, often called Graves's disease or Basedow's disease, is a complicated affection in which, in its typical form, protrusion of the eyeball is associated with enlargement of the thyroid gland, functional disturbance of the heart, and marked nervous and nutritive derangement. Though cases presenting this association of symptoms had previously been reported by Parry and others, the first systematic description of the disease now known as exophthalmic goitre was given by Graves in

1835, and his name is associated with it by English, American, and some French authors; while the Germans claim that Basedow was the first to describe it accurately (Casper's *Wochenschrift*) in 1840, and always speak of it as Basedow's disease.

The exophthalmus is not usually so excessive as that met with in cases of abscess or tumor of the orbit, but in a few instances has been so great as to prevent the lids from closing over the cornea. The effect of the protrusion of the ball is, in a large proportion of cases, heightened and the deformity much increased by an associated affection of the lids, a symptom to which attention was first called by von Graefe. The upper lid does not follow the movements of the ball as its axis is directed upward or downward, but remains fixed and more or less retracted, exposing the sclerotic and giving a staring and startled expression to the patient. This is due to contraction of the small, flat muscular fibres, extending from the lid back into the orbit, which were discovered by Müller and are known by his name. They are of the unstriated kind and are under the control of the sympathetic nerve. Sometimes, also, reflex contraction of the orbicularis from irritation of the eye is diminished, and winking is absent or incomplete. These lid symptoms are not constant, but are sometimes found when the disease is but slightly developed, and may be valuable indications in doubtful cases. The ball can be forced back nearly or quite to its normal position by pressure with the fingers, but projects immediately when the pressure is removed. Vascular bruit has been detected with the stethoscope by Snellen. Diplopia from displacement of the visual axes may occur, even as an early symptom, and, in some advanced cases, continued stretching produces paresis of the external muscles of the ball. There has been much discussion about the condition of the pupil; some cases have been reported in which it was dilated, and a few in which it was contracted, but, without doubt, it is usually unaltered. Vision is not generally impaired. The ophthalmoscope has occasionally shown retinal hæmorrhages, and Becker (*Klin. Monatsblatt für Augenheilk.*, 1880) has observed pulsation of the retinal arteries in some cases, but, as a rule, there is little or no change in the fundus beyond a dilatation of the retinal veins, and even this is not constant. Both eyes are almost invariably affected. Cases have been reported in which one only was involved, but this is so rare that Eulenberg thinks that some suspicion must remain in respect to the diagnosis. Slight keratitis, with conjunctivitis, is common in severe cases, but blindness from ulceration of the cornea is a rare occurrence. Some authorities attribute this ulceration to simple exposure of the cornea from excessive exophthalmus, but it is more probably an instance of so-called neuro-paralytic keratitis, due to a disturbance of nutrition resulting from the obscure neurosis that lies at the bottom of all the manifold symptoms of this disease. This is the view taken by Graefe and others, who consider the corneal affection a result of paralysis of the "trophic" fibres of the ophthalmic branch of the fifth nerve; the corneal sensibility being lost or retained according as all the fibres of the nerve, or the trophic only, are involved. Some authors, among them Charcot, are disposed to think that the corneal inflammation is produced by irritation of the nerve (see Neuro-paralytic Keratitis, Harlan, *Am. Jour. of the Med. Sci.*, April, 1874).

In nine cases out of ten the subjects of the disease are females, usually adults under thirty years of age, but a few instances in children under ten have been recorded. Male patients are generally older and their attacks are likely to be more severe. Most cases of corneal ulceration have occurred in males.

The exophthalmus usually disappears entirely after death, and no constant lesion is discovered by post-mortem examination of the orbit. Fatty degeneration of the muscles, from disuse and stretching, has been noted; and hypertrophy of the orbital fat has been found in some cases, but it may be considered an accidental result of the vascular engorgement which seems to be the cause of the protrusion of the eyeball.

The *pathology* of exophthalmic goitre is still very far from being a settled question. The first observers held that anæmia and chlorosis played the most important part in its inception. Others have thought that the heart was the starting-point, while more recent authorities unite in considering the disease a neurosis. Eulenberg ("Ziemssen's Cyclopædia," vol. xiv.), while he upholds the neurotic theory, regards "the question of localization in definite sections of the nervous system (especially in the cervical sympathetic and its centres) as not yet solved and at present unsolvable." Perhaps the most commonly accepted theory is lesion of the cervical sympathetic, the goitre and exophthalmus being attributed to dilatation of vessels from vaso-motor paralysis, and the cardiac symptoms and eyelid phenomena to irritation of the excito-motor fibres of the heart and of the sympathetic branches of Müller's muscles. Aside from the obvious objection to attributing some symptoms to paralysis, and others to irritation, and the absence of constant post-mortem lesions to support this view, all the symptoms are not satisfactorily explained by this theory, and exophthalmus has never been produced by section of the sympathetic. Some authors (Vulpian, Panas, etc., *Arch. d'Ophthal.*, 1881; Hammond, "Diseases of the Brain") maintain that the primitive seat of the disease is bulbar or central, and this view finds confirmation in the co-existence of various nervous symptoms, mental disturbance, and sometimes ophthalmoplegia, the almost constant participation of the heart, and the occasional occurrence of sugar in the urine. More than this, Filehne has succeeded in producing the symptoms of exophthalmic goitre in rabbits by wounding the restiform bodies (Fitzgerald, *Dublin Journal*, vol. lxxv).

Cases recently reported by Hack and Boboni (*Annales d'Oculist.*, t. 96, p. 260) indicate that exophthalmic goitre may be caused by the reflex irritation excited by chronic disease of the nasal cavities—a lesion to which much attention has been given, of late, as the origin of various other neuroses. Cauterization of the hypertrophied mucous membrane of the turbinated bones was followed by decided amelioration of all the symptoms of the disease in one of these cases, and in the other by entire disappearance of the exophthalmus, with progressive diminution of the thyroid enlargement and improvement in the cardiac affection.

For an account of the general symptoms, treatment, etc., see article Exophthalmic Goitre, in vol. ii., by Dr. Allan McLane Hamilton.

A few cases of "*periodic exophthalmus*" have been reported. In these cases the protrusion of the ball was monocular, occurred only on stooping, and could be satisfactorily explained by the supposition of a varicose condition of the ophthalmic veins.

Pulsating Exophthalmus, a comprehensive term based on convenience rather than on scientific accuracy, is now quite generally used to include a large class of cases dependent upon different pathological conditions, which in the present state of our knowledge it is always difficult and generally impossible to distinguish positively during life.

Symptoms.—There is protrusion of the eyeball, and pulsation is evident to the touch and sight. Above the eye, and beneath the upper and inner margin of the orbit, is a rather firm, elastic tumor also pulsating. The patient complains of a puffing or whirring noise in the head, and an aneurismal bruit is heard, on auscultation, over the eye and temple, and sometimes over the whole side of the head. In some cases this sound has been audible at a distance of several feet from the patient. There are usually distention and pulsation of the supra-orbital vein, and sometimes of the infra-orbital also. When the carotid is compressed in the neck the pulse and bruit cease, the tumor becomes soft, and the eye can be pushed back into the orbit. The hollow between the ball and the orbital arch is obliterated. The conjunctiva is congested, and, in many cases, a tumor is formed by intense chemosis of its lower fold, which projects beyond the lid. There may be no decided ophthalmoscopic changes, but the retinal vessels are usually congested, and the disk is sometimes found swollen as a result of pressure upon the

optic nerve in the orbit. Pain may be slight or severe. Vision is not generally much affected in recent cases, but the eye has often been destroyed by long-continued and excessive pressure. The symptoms usually appear suddenly, after direct injury to the orbit or a severe blow upon the head in traumatic cases; or during violent effort, as in childbirth, in cases of spontaneous origin. They have not been noticed, however, in a number of traumatic cases until some weeks or months after the injury.

In several spontaneous cases the patients have been roused from sleep by a loud sound like the report of a pistol.

Progress and Termination.—The deformity and inconvenience are so great, and the danger to the eye and to life is so decided, that few cases have been allowed to pursue a natural course, uninterrupted by more or less active treatment. As a rule, the character of the affection is chronic, and some cases have undergone little or no change in the course of years. In others, the eye has been destroyed by sloughing of the cornea and general ophthalmia. The causes of death include erysipelas, complications of brain and heart, and hæmorrhage. Of the last class, in the cases of Hussey and Critchett (*O. H. R.*, vol. ii., p. 127; *Med. Times and Gaz.*, December, 1854), the patients died of hæmorrhage directly from the orbit, and in one of Nélaton's (*Lancet*, 1873), profuse epistaxis, resulting from fracture of the body of the sphenoid bone and rupture of the carotid, was the cause of death. In 1876 ("Trans. Internat. Med. Cong.") I reported a case of spontaneous cure, and gave abstracts of six other cases recorded in literature up to that time, and I find three others reported since:

1. Bitsch (*Klin. Monatsbl. f. Augenhk.*, xvii., 1879): Exophthalmus, murmur, pulsation. Probable spontaneous rupture of carotid in cavernous sinus. Cure by extra- and intra-ocular inflammation.

2. Gauran (*Gazette des Hôpitaux*, October, 1883): Aneurism of both orbits, caused by a fall upon the head, cured spontaneously.

3. Glascott (*Brit. Med. Jour.*, November 25, 1882): "Arterio-venous aneurism of orbit," lasting two years. Spontaneous cure in the course of phlegmonous inflammation of the face and head.

This makes a total of ten cases, to which might be added several others in which the effect of remedial measures was doubtful.

Pathology.—The typical symptoms of "pulsating exophthalmus" are protrusion of the eyeball, pulsation, and aneurismal bruit, and all cases presenting these symptoms were formerly classed as "orbital aneurism." Following the view maintained by Travers, in his report of the first case in 1809 ("Med. Chirurg. Trans.," vol. ii.), for thirty years writers generally held that these cases of so-called aneurism of the orbit were all of the anastomotic variety. Then Busk's paper (*ibid.*, vol. xxii.) threw a doubt on this, and most authors thought that they were of the ordinary spontaneous or traumatic kinds, affecting the ophthalmic artery, until Nunneley, in 1864, maintained that in the great majority of such cases of protrusion of the eyeball there is no disease whatever in the orbit, but that the symptoms depend on obstruction to the return of blood through the ophthalmic vein. Though there is no positive proof that such a thing as an aneurism of the orbit has ever existed, it is, of course, not an impossible condition.

A review of the now very extensive literature of the subject makes it seem probable that pulsating exophthalmus may be produced by true arterio-venous or anastomotic aneurism of the orbit; aneurism of the carotid artery, or of the ophthalmic at its origin; aneurismal varix between the carotid and the cavernous sinus; thrombosis of the ophthalmic vein or cavernous sinus; dilatation of the sinus; or obstruction of the return of venous blood by growths at the bottom of the orbit or behind it. The protrusion of the ball is the result of venous engorgement; while the pulsation and bruit are communicated from the carotid, or produced by the rush of blood into dilated vessels confined in a bony cavity and with obstructed outlets, or are symptoms of an aneurismal varix of the orbit due to a communication between the carotid artery and cavernous sinus. From a study of the comparatively few post-mortem records, and the histories of a large number of cases in which the patients have survived, I am convinced that marked pulsation and bruit have most frequently been produced by aneurismal varix of the orbital veins. In three traumatic cases direct communication between the carotid artery and cavernous sinus was found after death; and in three spontaneous cases post-mortem examination showed that there had been rupture of diseased carotid arteries in the cavernous sinus. In a number of cases the diagnosis of arterio-venous communication in the cavernous sinus has been made, with more or less confidence, during life.

In a traumatic case, reported by Knapp, this diagnosis was subsequently confirmed as positively as it could have been by a post-mortem examination. Ligature of the carotid gave partial relief, but, nearly two years afterward, there was a recurrence of the orbital disease, with great increase of the pulsating tumor, enormous protrusion of the eye, and sloughing of the cornea. After extirpation of the eyeball, the orbit was found to be filled

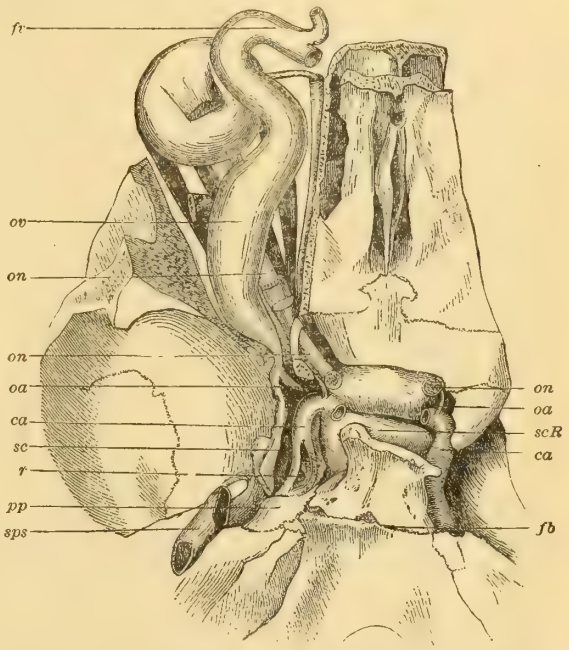


FIG. 2643.—*sc*, The dilated cavernous sinus, opened from above; within this, the internal carotid (*ca*), which is cut open above to show the perforation in the under and outer side of its wall (*r*); *fb*, the fracture in the sphenoid bone; *pp*, detached spicula from the point of the petrous bone; *scR*, sinus circularis Ridleyi; *sps*, a part of the dilated superior petrosal sinus; *ov*, dilated ophthalmic vein; *fv*, vena frontalis; *oa*, ophthalmic artery; *on*, optic nerve. (After Delens.)

with an irregular pulsating mass, which was removed entire, and was found to consist chiefly of an aneurismal varix (*Arch. Ophthal.*, vol. xii.). The accompanying illustration shows the condition found, post-mortem, in one of Nélaton's cases (Sattler, Graefe and Saemisch "Handbuch," vol. vi., p. 848). There was a fracture of the sphenoid bone and of the petrous portion of the temporal, and a small hole in the carotid communicating with the cavernous sinus. The sinus and the ophthalmic vein were dilated and tortuous.

It must be confessed that serious objections can be urged against the use of the terms "pulsating exophthalmus" and "vascular protrusion," and perhaps it may be well to discard them when accurate and definite diagnosis is possible. It is quite true that, as Mr. Curling said in opposing the introduction of these terms, "to class affections of very different character under one common head, taken from a prominent symptom, is not calculated to advance surgical pathology and practice:"

but it is equally true that such advance is not promoted by feigning a positive knowledge when we have it not, and giving a definite name to indefinite conditions. Confession of ignorance is an essential preliminary to the acquisition of accurate information, and the lesions producing the prominent symptoms of protrusion of the ball and pulsation may be conveniently and profitably classified with reference to these symptoms, until the accumulation and study of post-mortem records throw more light upon the subject.

In 1875 ("Trans. Am. Ophthal. Soc.") I published abstracts of fifteen cases, including the imperfectly reported one of Guthrie, in which post-mortem examinations had been made. As in two of these cases (Lenoir's and Hamilton's) the symptoms had been produced by vascular malignant growths of the orbit, this number should be reduced to thirteen. In the papers since published, of Rivington ("Med.-Chirurg. Trans.," vol. lviii., p. 282) and Sattler (Graefe-Saemisch, vol. vi.), are quoted the following two cases that escaped my search:

1. Hirschfeld (*Gazette des Hôpitaux*, 1859, p. 51; *Lancet*, 1873): Traumatic; post mortem, a blood-clot found in the cavernous sinus, and this clot covered a small circular hole in the carotid, which looked as if it had been punched out and was occupied by a string of decolorized clot about two inches long passing into the mass of coagulum.

2. Oettinger (Sattler, *ibid.*): Spontaneous; post mortem, no change in the arteries, but traces of inflammatory processes in the retro-bulbar tissues, and obliteration of the ophthalmic vein.

I can find only the three following reports of post-mortem examinations recorded since 1875:

1. Blissig, 1876 (Sattler, *ibid.*): Traumatic; post mortem, "decided dilatation of the internal carotid in the cavernous sinus." As the common carotid was tied eight weeks after the injury, and the patient lived five weeks after the operation, Sattler seems to think that the cause of the dilatation may have been a wound in the artery that had closed.

2. Schlaefke, 1879 (*Arch. für Ophthal.*): Traumatic; post mortem, dilatation of the cavernous sinus and aneurismal enlargement of the cavernous portion of the carotid artery; all the orbital veins enormously distended and the frontal and supra-orbital dilated.

3. Coggin, 1883 (*Arch. of Oph.*): Spontaneous; post mortem, marked aneurismal dilatation of the cavernous portion of the carotid artery, ophthalmic vein not much enlarged. In this case the pulsation and bruit seem to have been communicated from the carotid aneurism.

This makes a total of eighteen post-mortem records, an analysis of which gives the following result:

True aneurism of *both* ophthalmic arteries in the orbits (doubtful), 1; post-orbital aneurism of ophthalmic artery, 1; aneurism of carotid in cavernous sinus, 1; dilatation of carotid in cavernous sinus, 4; wound of carotid in cavernous sinus, 3; thrombosis of cavernous sinus and ophthalmic vein, 5; dilatation of cavernous sinus and ophthalmic vein, 2; pressure on cavernous sinus and ophthalmic vein by new growth, 1.

The case considered doubtful is that recorded by Guthrie ("Operative Surgery of the Eye," p. 158, 1823). The following is his report: "I have seen one case of true aneurism of the orbit which terminated fatally. The symptoms were similar to those above mentioned (cases of Travers and Dalrymple), but no tumor could be perceived; the hissing noise in the head could be distinctly heard. On the death of the patient an aneurism of the ophthalmic artery was discovered on each side, about the size of a large nut. The vena ophthalmica cerebralis was greatly enlarged and obstructed where it passes through the foramen lacerum, in consequence of a great increase in size which the four recti muscles had attained, accompanied by an almost cartilaginous hardness, which had been as much concerned in the protrusion of the eye as the enlargement of the vessels." The description is so meagre and loose, and the post-mortem appearances reported are so very peculiar, that this case is not generally considered as affording positive proof of the existence of true orbital aneurism.

An aneurism of the ophthalmic, the size of a hazel-nut, just at the entrance of the artery into the orbit, was accidentally discovered in a cadaver by Carron du Villards (Sattler, *ibid.*, p. 846). There was no history of the case, and it is not even known that it was one of pulsating exophthalmus.

Finally, in one of Nunneley's spontaneous cases ("Med.-Chir. Trans.," vol. xlviii., p. 28) a circumscribed aneurism of the ophthalmic artery, as large as a hazel-nut, at its origin from the carotid was discovered. The post-mortem was made nearly five years after a successful ligation of the carotid. The arteries of the orbit are described as unusually small. These three cases comprise all the post-mortem evidence of any connection of the ophthalmic artery with the symptoms of pulsating exophthalmus.

While the above was passing through the press, I met, at last, with a report of what seems to have been a veritable case of "orbital aneurism," carefully examined and treated during life and verified by autopsy—the only one, so far as I know, on record. The report was read at the last meeting of the British Medical Association by Dr. Alexander Dempsey, of Belfast, and may be found in the *British Medical Journal* of September 18, 1886. The symptoms, which first appeared a few hours after childbirth during violent vomiting, differed little from those observed in the reported cases of carotid aneurism which have occurred under somewhat similar conditions. The common carotid was tied, and death resulted from secondary hæmorrhage from the wound in the neck and bleeding from the aneurism through the cornea.

There was an aneurism of the internal carotid artery, at the point of origin of the ophthalmic, which had no communication with the cavernous sinus. Its diameter at its widest part was from one-half to three-fourths of an inch. The orbital aneurism is described as follows: "The ophthalmic artery, from its origin, was also very considerably dilated, I should say to fully four times the size of the opposite one, and on tracing it into the orbit we found an immense sacculated aneurism developed on its superior aspect. The sac would contain easily a mandarin orange. In its centre there was a post-mortem clot, but around its circumference there was a firm, laminated fibrous ante-mortem clot which was a complete cast of the sac, except at its anterior part, where it was open and communicated with the eyeball by a large opening at the upper, back, and outer part of the globe. The contents of the globe had escaped, when hæmorrhage had taken place, through the cornea. The superior petrosal sinus of the opposite side was distended, but the other sinuses of the brain appeared normal. The arteries of the circle of Willis were dilated, especially the anterior communicating. The veins of the orbit were all very much enlarged, especially those at the inner angle of the eye."

While it would seem that any obstruction to the return of blood by the ophthalmic vein may produce the symptoms of pulsating exophthalmus, even complete obstruction by thrombosis of the sinus does not, by any means, always do so. In a case reported by Lloyd (*Ophth. Rev.*, vol. iii., No. 37) there was aneurism of both the basilar artery and the internal carotid, and the cavernous sinuses of both sides were blocked with firm fibrinous red thrombi; yet there had been but slight exophthalmus, which lasted only a few days, and never any pulse or bruit. Lloyd attributes the recession of the globe to the establishment of collateral circulation; and Sattler says that when an intra-cranial aneurism is formed gradually it may completely compress the ophthalmic vein and cavernous sinus without producing either pulse or exophthalmus.

Though *aneurism by anastomosis* was formerly the favorite diagnosis in cases of so-called "orbital aneurism," it has never been verified by post-mortem observation, and more recently its occurrence has been doubted. The following congenital case (Harlan, "Trans. Am. Ophthal. Soc., 1875," and "Internat. Med. Congress, 1876") seems scarcely to admit of any other probable view

than that of aneurism by anastomosis, or cirsoid aneurism. The patient was a healthy man, twenty-five years of age. The left eye had always been prominent and the left side of the head larger than the right. From his earliest recollection there had been a rushing sound in his eye and head. The left eye was enormously protruded and forced downward and outward. No useful vision. Whole left side of face hypertrophied. Above the eyeball, and lying more to the inner side, there was a distinct tumor of almost cartilaginous density. Pulsation was strong enough to communicate an evident motion to the head of the auscultator; and a loud aneurismal bruit was not only an annoyance to the patient, but could be heard by others some distance from his head. There was a doughy swelling of the soft parts, extending about an inch above the orbit, in which strong pulsation could be felt. Pressure upon the left carotid stopped all pulsation, and the tumor became soft and could be pressed back into the orbit. The supra-orbital and frontal arteries were much distended, and pulsated strongly, and this aneurismal condition extended down the angular branch of the facial on the right side. A

Fig. 2644.—Congenital Aneurism by Anastomosis of Orbit.

vascular tumor, formed by engorgement and hypertrophy of the inferior conjunctival fold, almost concealed the cornea, and had several times bled quite freely; this was removed by constriction with silk ligatures. Some months later, the patient presented himself with violent acute inflammation of the contents of the orbit. The tumor was increased to twice its former size, the exophthalmus was enormous, the eye could no longer be covered by the lids, and the cornea sloughed. In a few weeks the tumor had completely consolidated and was rapidly diminishing in size. In this case the congenital origin, the hypertrophy of the whole side of the face, the involvement of the external vessels, and the evident extension of the disease beyond the orbit to the subcutaneous tissue of the brow point to aneurism by anastomosis, or cirsoid aneurism. The only other possible supposition is a rupture of an aneurism of the carotid in the cavernous sinus and consequent aneurismal varix of the orbit, but the history of the case makes this more than improbable.

Vascular malignant growths of the orbit may produce the symptoms of pulsating exophthalmus, and in at least two such cases the carotid artery has been tied for the cure of orbital aneurism. The bruit in these cases may be very decided, but is not likely to be so loud; the tumor shows more tendency to extend toward the temporal side of the orbit, and is less reducible after compression of the common carotid than in cases of pulsating exophthalmus dependent upon the causes that we have been considering. Of course, multiple tumors and other indications of malignant disease should be carefully looked for.

Treatment.—The long continuance of some cases without material change, and the recovery of a few without interference, or with only hygienic care and medical treatment, should discourage resort to serious surgical procedure when there is no immediate danger or decided suffering or deformity, though these conditions may, perhaps, be considered exceptional. Milder remedies should, at least, be given a trial first.

In a very decided traumatic case reported by Dr. Holmes, of Chicago (*Am. Jour. Med. Sci.*, July, 1864), complete cure followed the exhibition of veratrum viride and extract of ergot for two months; and Dr. Freeman, of Canada (*ibid.*, 1866), reports the cure of a spontaneous case, in a few weeks, by application of cold, direct pressure on the swelling, and the use of digitalis. In a few cases, digital compression of the carotid artery has effected a cure.

Compression of the common carotid has been frequently tried. In my own traumatic case ("Trans. Am. Oph. Soc.," 1875) the patient himself kept up intermittent compression for several hours daily. At the end of six months there was decided improvement, in two years all prominence of the eye had disappeared, and some months later he was entirely cured. Of course, this case is open to the suspicion of spontaneous cure, but the patient always experienced great immediate relief from the compression, and was confident that it was the cause of the final cure. It is almost impossible to apply instrumental compression effectually, and it has never been successful. According to Sattler, of twenty-nine cases treated by compression, continued or intermittent, permanent cure can be claimed in only four, though more or less improvement followed in five others.

Galvano-puncture has been tried in two cases unsuccessfully (Petréquin, *Gazette Médicale*, 1846, and Bourguet, *ibid.*, 1855). In Petréquin's case the patient died.

Acupressure, with hot needles, has failed in one case.

Injection of ergotin has been tried once without success.

Injection of coagulating fluids has effected a cure in three cases (Bourguet, *loc. cit.;* De Sormeaux, quoted by Rivington, "Med. Chir. Trans." vol. lviii.; and Brainerd, *Lancet*, 1853). Bourguet and De Sormeaux used tincture of the chloride of iron, and Brainerd used the lactate.

Ligature of the common carotid has proved by far the most efficient means of treatment, and a number of brilliant successes have been reported. It must be remembered, however, that it is not without its chances of failure and its dangers of a fatal issue. Sixty-three ligations of the common carotid, performed on 61 patients, in the treatment of pulsating exophthalmus, have been compiled by Sattler. In 17 cases (26.98 per cent.) the operation had little or no permanent effect; 8 (12.70 per cent.) resulted fatally; and in 38 (60.30 per cent.) the result was favorable.

Extirpation of the orbital tumor is a bold procedure and has a brief but favorable record. In his report of a successful case of this operation Knapp (*Arch. of Oph.*, vol. xii., No. 2) makes the following reference to three others: "Among the different methods recommended and practised, I chose the one, extirpation, which I find mentioned in Sattler's compilation of one hundred and six cases only three times, namely, 1, Morton's case (Sattler, No. 70), excision of the whole contents of the orbit, excessive hæmorrhage arrested by glowing iron and compression, recovery; 2, Frothingham's case (Sattler, No. 80), ligation of common carotid, retardation of increase for three years, then rapid growth, extirpation with very considerable hæmorrhage; 3, Hanson's case (Sattler, No. 106), ligation of common carotid, return of symptoms as early as the second day, three weeks later extirpation of the tumor with preservation of the globe, profuse hæmorrhage arrested by perchloride of iron."

Vascular Protrusion without Pulsation.—As has already been stated, in thrombus of the cavernous sinus, though more or less exophthalmus is almost invariable, pulsation and bruit may be absent, and this is, perhaps, the rule. *Cavernous tumors* of the orbit have been met with in a few cases. A typical one is described by Graefe (*Arch. für Ophthal.*, t. viii.) in which the whole mass was removed with the eyeball. Wecker ("Maladies des Yeux") extirpated a somewhat similar tumor without removing the ball. In each of these cases the tumor consisted of spongy tissue encysted in a dense capsule. There has never been pulsation in any well-established case of cavernous angioma of the orbit. The only remedy is extirpation. The exophthalmus in goitre may be considered of the nature of vascular protrusion without pulsation.

Simple Angioma (Telangiectasis) sometimes extends into the orbit from the skin of the lids, forming a soft, slightly compressible tumor. The best treatment is extirpation or electrolysis. Simeon Snell has lately reported several successful cases of the latter, and considers it especially applicable when the disease extends deeply into the orbit (*Lancet*, July, 1886). Frequent repetition of the operation is usually necessary.

Encephalocele.—Though encephalocele, or meningocele, of the orbit is extremely rare, it is important to bear in mind the possibility of its occurrence. This is well illustrated by a case described by Guersant ("Maladies des Enfants," p. 246). The patient was examined by a number of the fellows of the Surgical Society of Paris, who all agreed in considering the case one of vascular tumor, and in advising treatment by setons. The patient died with cerebral symptoms, and a post-mortem examination showed that the tumor consisted of brain-substance, covered by membranes, which had passed through the fronto-ethmoidal suture. It may be extremely difficult to distinguish such a tumor from a vascular swelling, particularly as, if of considerable size, it would be likely to pulsate; and, if situated behind the ball, it would cause exophthalmus. Its congenital character should excite strong suspicion; it would be increased in size by forced expiration and much diminished by pressure. Other congenital defects would be likely to occur in connection with it. In a case in which Oettingen (*Klin. Monatsblatt*, February, 1874) diagnosticated a spheno-orbital meningocele associated with some angiomatous tumor, there was also a small occipital meningocele, which bulged out when the orbital tumor was pressed upon; and tapping the latter with the finger communicated an impulse to the former. Even here, however, the author could not feel quite sure of his diagnosis, and suggested the possibility of a vascular tumor communicating with the intra-cranial cavity by means of absorption of the orbital wall.

Tumors of the Orbit.—The remaining tumors of the orbit may be classed as cystic and solid. The most prominent *symptom*, and one that, in greater or less degree, is necessarily constant when the tumor is situated behind the ball, is exophthalmus, which will vary in extent and direction with the size, position, and character of the tumor. If the latter is situated outside the muscular pyramid it will protrude the ball in a direction opposite to its own position; if within the pyramid, it will press the eye more directly forward, and will participate more in its movements. Diplopia is a frequent and sometimes an early symptom. The motion of the ball is not necessarily affected by a small tumor, but is limited by a large one; and, if this is outside of the muscles, the limitation will be chiefly in the direction of its site. Complete immobility of the eye suggests malignant growths, as their well-known tendency is to involve and include the neighboring structures. Paralysis of the orbital muscles often causes squint, ptosis, etc., and compression or stretching of the optic nerve may produce blindness in an otherwise sound eye; or, the nerve may be involved in a morbid growth. Injury to the ciliary nerves may be shown by dilatation of the pupil, or may result in sloughing of the cornea from neuro-paralytic keratitis. Finally, the eye may be destroyed by ophthalmitis resulting from interference with its nervous and vascular supply. Pain is a very variable symptom, being sometimes severe and sometimes absent. It is in some cases referred to the bottom of the orbit, in some it appears as frontal or ciliary neuralgia, and in others as general headache. The ophthalmoscopic appearances are sometimes negative, but often show some signs of pressure upon the optic nerve, such as venous congestion and arterial contraction, retinal hæmorrhage, "choked disk," or optic atrophy.

Diagnosis between tumors of the orbit and periostitis or phlegmon, vascular protrusion and disease of the neighboring cavities often presents serious difficulties. The mode of onset of the disease, whether sudden or slow, and accompanied or not by acute inflammatory symptoms, is an important consideration, but will not always be a safe guide in case of chronic periostitis or chronic abscess (see p. 361). Vascular protrusion may generally be distinguished by the fact that the ball can be pressed back, by the effect of compression of the common carotid, the dilatation of vessels beyond the margin of the orbit, and the existence, in some cases, of pulsation and bruit. It must be remembered that pulsation and bruit have led to mistakes in cases of highly vascular malignant growths. Careful inquiry should be made as to predisposition to syphilis or malignant disease. Valuable information is obtained by careful exploration with the finger pressed well back behind the ball. Osseous growths and solid tumors attached to the walls of the orbit, if not too deep in the cavity, can usually be distinguished in this way with a considerable degree of certainty, though periostitis will sometimes simulate the latter closely. An effort should be made to decide, by palpation, whether the tumor is hard, elastic, or fluctuating, whether fixed or movable, and if situated outside of or within the muscular pyramid. Enlargements of the lachrymal gland, on account of their position, can generally be recognized with comparative ease. It may sometimes be necessary to determine the character of the contents of a supposed cyst by puncture. The nasal cavities and the vault of the pharynx should be explored with the mirror.

Cystic Tumors.—Professor Gross ("System of Surgery") says of cysts: "They may be classified according to their mode of development, first, as retention cysts, or those which arise from the retention and accumulation of the normal secretion of glands; second, as exudation cysts, or those which result from the distention of closed cavities; third, as dermoid cysts, or those which arise from fœtal inclusions; fourth, as cystomas, properly so-called, or cysts of new formation, which are possibly due to cystic degeneration of the cells of the connective tissue; fifth, extravasation cysts, or those which form around effused blood, and sixth, as hydatid cysts." All of these forms are likely to occur in the orbit.

The most common true retention cysts found in this locality are the *sebaceous*. They probably arise from the skin, though their connection with this point of origin may not always be traceable. Cysts of the lachrymal gland ("dacryops") are rare. They are due to retention of the tears from obstruction of the ducts. The swelling enlarges with increased secretion of tears and its character is not usually difficult to recognize.

Dropsy of Tenon's Capsule has been described as a form of exudation cyst, but its pathology is somewhat doubtful, and its occurrence is, to say the least, extremely rare. *Serous cysts* have been attributed to disease of the bursa in the trochlea of the superior oblique muscle, or of those sometimes found on the levator and superior rectus; and Wecker considers it probable that most serous orbital cysts arise in this way. This view is probable, but lacks proof in pathological anatomy. Congenital *dermoid cysts* are found more frequently in the orbit than elsewhere. It is generally stated that their usual seat is near the external angular process of the frontal bone, but of 51 cases collected by Berlin 27 were on the nasal side, 12 on the temporal, 8 below, and 4 above. Their walls are of a cutaneous structure, and contain sebaceous matter and sometimes hair. Teeth have also

been found in them. Wecker (*loc. cit.*) says that serous cysts may form voluminous tumors, which enlarge the orbit by excessive pressure, and extend through foramina into the cranial cavity. He, however, gives but one instance, quoted from Delpech. The cyst was prolonged into the cranial cavity through the optic foramen, which was sufficiently enlarged to admit the index finger. Inflammation of the sac, induced by incision and exploration, extended to the brain and resulted in death. It was found that a diverticulum of the cyst, three inches long, had encroached upon the under surface of the cerebral lobe, and had contracted firm adhesions with the meninges. This case, which is also quoted by Mackenzie as one of hygroma, Berlin thinks must have been a meningocele. If serous tumors of very large size have ever existed in the orbit, it is not likely that they originated in diseased bursæ, which are never known to produce such tumors elsewhere, but it is more probable that they were *cysts of new formation*, similar to the so-called hydrocele of the neck, whose pathology is not well known. *Hæmatoma* of the orbit has already been referred to in discussing hæmorrhage. *Echinococci* and *cysticerci* have been found in the orbit. Though some of the text-books refer to them as if not very infrequent, they are, in fact, extremly rare. Berlin says that, with an experience of forty thousand eye patients, he has not met with a single case of either, but that thirty-nine more or less reliably reported cases of the former are to be found in literature, while he has been able to find reports of only three rather doubtful cases of cysticerci in the orbit, though they are comparatively frequent in the eyeball and its appendages.

Solid Tumors.—As almost every form of tissue is represented in the orbital cavity, almost all kinds of tumors are possible there. In addition to the vascular and cystic tumors referred to above, the following forms of more solid growths have been described by authors: Lipoma, fibroma, enchondroma, carcinoma, osteoma, neuroma, and sarcoma. A discussion of the histology and pathology of these various diseases is, of course, beyond the scope of the present article. Epithelioma may extend into the orbit from the skin of the lids. Enchondroma and carcinoma are very rare, and fibroma and neuroma not much less so. Lipoma is frequently referred to in a general way, but only a few cases have been recorded. Osteoma is, comparatively speaking, not very uncommon. The larger proportion of solid tumors met with in the orbit belong to some of the numerous forms of sarcoma. Berlin (*loc. cit.*) says: "When we perceive in any part of the orbit a solid tumor with a nodulated surface, which does not fluctuate or pulsate, is not compressible or stone hard, is not in probable connection with the brain, and does not arise from the lids, the ball, the lachrymal gland, the optic nerve, or the neighboring cavities, we may decide on the diagnosis that we have to do with a sarcoma of the orbit."

Some of the most extensive growths that attack the orbital tissue originate in the eyeball. By far the most common intra-ocular tumors are retinal glioma and choroidal sarcoma, and these, when they have once passed the fibrous envelope of the ball, extend rapidly in the orbit. The former generally ends fatally by direct extension to the brain, or by metastasis to that or some other organ. This sometimes happens, too, in the case of sarcoma, which also frequently causes the most frightful local destruction of bone as well as of soft parts.

Enlargements of the lachrymal gland may be due to acute or chronic inflammation. In the case of the former there is redness and swelling of the upper lid, congestion of the conjunctiva and considerable pain. It frequently ends in suppuration, which is sometimes followed by fistula. In the chronic form the inflammation is usually indolent, and the swelling may be mistaken for a neoplasm.

Simple hypertrophy of the lachrymal gland is rare. It is said to result from repeated attacks of inflammation, and to occur sometimes spontaneously or even congenitally. Exact observations in regard to it are wanting.

Various forms of degeneration of the gland have been met with, the most frequent of which, according to some authorities, is the adenoid. There are a few well established cases of sarcoma and carcinoma. I exhibited a sarcomatous lachrymal gland as large as a hen's egg, at the meeting of the American Ophthalmological Society, in 1882, and Dr. Knapp referred to one nearly as large, which he had recently removed. There were no adhesions in either case and the tumors were easily enucleated. The prognosis as to the probability of a return of the disease is favorable.

The position of such tumors makes their diagnosis comparatively easy. The ball is usually forced downward, forward, and inward; but in the case referred to above its direction was decidedly outward. This exceptional symptom, which is probably unique, may be accounted for by the unusual size of the tumor and its development toward the inner side of the orbit (Fig. 2645).

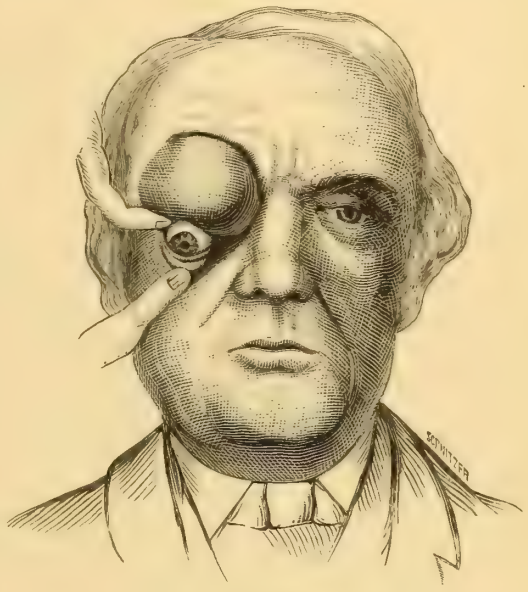


Fig. 2645.

The ball resumed its normal position in a few weeks after the operation.

Tumors of the optic nerve have been reported in thirty odd cases, and have consisted of glioma, myxoma, sarcoma, endothelioma, and carcinoma (Knapp, "Trans. Internat. Med. Congress, 1876," Berlin, Graefe-Saemisch). Graefe reported several cases and gave the following symptoms as diagnostic: Progressive protrusion of the eyeball, parallel to the axis of the orbit, or a little outward; preservation of the mobility of the eye; preservation of a layer of connective tissue between the eye and the tumor, and the integrity of the centre of rotation; soft consistence of the tumor; absence of pain; absence of subjective luminous sensations, and rapid abolition of vision. In some cases more recently reported there was more loss of mobility of the ball than Graefe seems to have met with, and in several there was severe pain in the eye and orbit, and the tumors have not always been of soft consistence. Valuable assistance in diagnosis can be obtained by palpation—pressing the finger deep into the orbit behind the ball.

Osteomata may grow immediately from the diploë of the bone, or originate in inflammatory exudations from the periosteum. In the former case they are likely to extend at the same time into the orbit and into one of the neighboring cavities. They vary in size from a mere nodule to a mass filling the whole orbit, and may be of cancellous structure or of ivory density. The latter is much the more common form. They have, in a few cases, occurred in both orbits at the same time. The etiology of orbital osteoma is very obscure. Syphilis, which might

naturally be thought a frequent cause, is an extremely rare and even doubtful one. Bony tumors of the orbit are of slow growth, and are injurious only by their mechanical effects, which, however, are sometimes serious enough. A few cases are reported in which a cure resulted from necrosis and spontaneous separation (Lediard, "Trans. Oph. Soc. United Kingdom," iii., p. 23).

In the *removal of orbital tumors* antiseptic precautions should be carefully carried out. If there is useful vision, or even a sound eye, the eyeball should be preserved whenever possible, unless its retention renders impracticable the thorough removal of tissues involved in malignant disease. It will usually be possible to retain the ball when the growth is outside the intramuscular space, and sometimes even when it is within it. This has been done, with satisfactory results, in the case of tumors of the optic nerve by Knapp and Grüning (*Arch. of Ophthal.*, iv., p. 323, and v., p. 508). To avoid the deformity of the resulting cicatrix, it is usually better, when practicable, to operate through the conjunctiva, and this will, of course, be necessary in the case of tumors within the muscular space. To gain room the external canthus may be freely incised, or the upper lid may be dissected back. In removing tumors situated well forward or attached to the orbital walls, or of large size, it may be necessary to make the incision through the skin of the lid. The handle of the knife will often be found of more use than its edge in freeing the growth from its attachments, and much of the operation can most conveniently be performed with a strong pair of blunt-pointed scissors, curved on the flat. Extensive malignant disease sometimes necessitates the removal of all the contents of the orbit, and the application of the chloride of zinc paste to its bared walls. Though such cases are extremely discouraging, in a few that were apparently desperate the operation has succeeded at least in securing some years of comfort to the patient. It may be necessary to resort to the actual cautery to check hæmorrhage, though this can usually be accomplished by hot water and compression. When extension of the disease to neighboring cavities renders its complete removal impracticable, the operation should never be undertaken. Exostoses may be removed with comparative safety when situated on the floor or inner wall of the orbit, but the attempt is rarely justifiable when the deeper parts of the roof are involved. Of sixteen cases, collected by Berlin, in which exostoses of the orbital roof were operated on, in six the patients died of meningitis. Knapp reports several cases in which osteomata of the roof, situated peripherally, were successfully removed ("Trans. Fifth Internat. Oph. Congress"). It has occasionally been found possible to cut these bony tumors with the pliers or to wrench them from their bases with the forceps, but usually the chisel and mallet will be found more efficient. The use of the dental engine has been suggested and may be applicable to some cases. The attachment of the base to the orbital wall is less firm than the structure of the tumor, and in operating this should be made the point of attack. The difficulties of the operation are greatly increased when the growth originates in the diploë and extends on both sides of the bone. Knapp (*Arch. of Oph.*, ix., p. 464) describes a method of shelling out such tumors within their periosteal envelope, by cutting, with the chisel, the orbital wall encasing them and removing them entire. He thinks the operation may be performed with success even though the exostosis project into the cranial cavity.

Injuries of the Orbit derive their greatest interest and importance from the fact that only a thin plate of bone separates this cavity from the brain. Punctured wounds of the roof of the orbit may very easily penetrate the intra-cranial cavity. Such injuries were formerly sometimes inflicted by the sword, while in more modern times the umbrella-stick has figured most prominently as the offending instrument. These, of course, are very fatal wounds. Out of fifty-two cases of perforation collected by Berlin (Graefe-Saemisch, vol. vi.) the patients survived in only eleven, and of these five suffered from subsequent effects. Great caution should be used in the treatment and prognosis of such cases, as the surgeon is liable to be misled by the innocent appearance of the external wound and the absence of immediate symptoms of an alarming character. Mackenzie relates several cases in which the patients walked considerable distances after receiving the injury and then fell dead.

The result of a *gun-shot wound* of the orbit will depend upon the direction that the ball takes. In a large proportion of cases the brain is injured and death ensues; but a ball passing obliquely through the temporal region may destroy one eye only, and cases are reported in which sight was entirely destroyed, without other injury, by balls crashing through both orbits behind the eyes. I met with one such case, during the late war, in which very little deformity resulted, and the external appearance of the eyes was not affected.

Fractures of the base of the cranium frequently extend into the walls of the orbit, generally the roof. In the post-mortem examination of eighty-six cases of fracture of the base, von Hölden found fracture of the orbit in seventy-nine (Berlin, *loc. cit.*). Blindness may result immediately from rupture of the optic nerve, or hæmorrhage in its sheath, or may be subsequently induced by neuritis. Intra-cranial hæmorrhage and hæmorrhage and emphysema of the orbit, as results of fracture of the orbital walls, have already been referred to.

It is important to remember that *foreign bodies*, even of considerable size, may easily escape detection in the orbit. A number of striking instances of this have been recorded. Mr. Carter has reported a case in which a piece of iron hat-peg, nearly three inches and a half long, remained concealed in the orbit for several weeks, without the knowledge of the patient. It was removed, and the eye remained uninjured. Hennen found a flattened musket-ball which had lodged in the orbit, without injury to the eye. Shot from fowling-pieces and chips of iron driven with force by the hammer or lathe sometimes pass through the ball and lodge in the orbit. Shot may become encysted and cause no irritation, and even larger and rough substances may give little indication of their presence. A man presented himself at the Wills hospital, in Philadelphia, with a wound near the corneo-sclerotic junction, but was very positive that the foreign body that inflicted it had rebounded. The eye was but slightly inflamed, and the patient continued to improve and would have been discharged if a little sympathetic irritation of the other eye had not been noticed. In enucleating the ball great difficulty was experienced in cutting the optic nerve, and a splinter of iron, one inch long, was found lying by its side.

Cases were formerly reported in which impaired vision was attributed to injury of the supra-orbital or infra-orbital nerve by blows upon the edge of the orbit, but it is probable that the ophthalmoscope would have revealed some intra-ocular lesion produced by concussion, or that a fracture involving the apex of the orbit may have injured the optic nerve. Contusion of these nerves is not now recognized as a cause of amblyopia.

Dislocation of the eyeball may be caused by a foreign body thrust into the orbit behind it. It has frequently been produced by the "gouging" thumbs of brutal fighters. The ball lies upon the malar bone and the orbicularis muscle contracts behind it, retaining it beyond the lids. The optic nerve is, of course, violently stretched, but is not usually permanently injured if the dislocation is soon reduced.

In the *treatment* of injuries of the orbit it is important to bear in mind the dangerous character of its anatomical relations, and the serious mischief that may easily be inflicted by probing. It is better to treat many trivial cases with unnecessary caution than to underestimate the danger of one that may have a serious or even fatal termination. Complete rest, cold applications, and sometimes leeching will be required in the early stages, and if pus forms subsequently, it should be allowed prompt and free escape. If incisions are necessary for the removal of foreign bodies, they should be made through the conjunctiva rather than through the lids, to avoid the danger of ectropium or other deformity that might follow the contraction of cicatrices. In reducing dislocation of the

eyeball, the upper lid should be stretched and drawn forward, while the ball is gently pressed back. It may be necessary to divide the external commissure. A compress bandage will be required to retain the eye in position for a few days.

Diseases of the Neighboring Sinuses may seriously affect the orbit by pressure upon its walls or extension into its cavity.

The *frontal sinus* is sometimes greatly distended by the accumulation of retained muco-purulent secretion in chronic inflammation of its lining membrane. The upper and inner wall of the orbit is bulged by pressure, and the eyeball is forced downward and outward. These accumulations are sometimes very extensive, and involve the ethmoid sinus or the frontal sinus of the other side by destruction of the intervening walls. Dr. Bull ("Trans. Am. Oph. Soc., 1885") reports a case of chronic abscess involving both frontal sinuses and the ethmoid sinus of one side, the result of an injury received fourteen years before. The disease may also result from direct extension of inflammation from the mucous membrane of the nose. The pus may finally escape into the nose, into the orbit, or externally, but the opening that gives it exit is not likely to be free enough to lead to a cure. The most common locality for spontaneous discharge is at the inner canthus, above the tendo oculi, and a permanent fistula is likely to result. When the bone over the swelling is very much thinned by distention and absorption it yields to pressure by the finger with a kind of crackling sensation, which has been well compared to that produced by pressure upon the lid of a tin box, and which will distinguish the case from one of solid growth. The sinus should be freely opened with a strong knife, or, if necessary, with a drill, near the inner canthus or beneath the superciliary arch, and a silver tube inserted, through which the cavity can be washed out frequently with disinfectant and stimulating solutions. It may be necessary to continue this treatment for several months before allowing the opening to close.

Similar distention of the *maxillary antrum* by fluid accumulation forces the floor of the orbit upward. It may result from any cause that produces chronic inflammation of the lining membrane of the cavity, but the most frequent cause is a diseased tooth. Pus may escape into the nostril, through the alveolus at the canine fossa, or into the orbit. When it enters the orbit it causes an infiltration and swelling of the lower eyelid, and finally a fistula. When there is a diseased tooth the best plan of treatment is to extract it and puncture the antrum through its socket; or, if the abscess points in the alveolar process an opening may be made behind the upper lip. In either case a tube should be inserted and injections used.

A few cases of retention tumor of the *ethmoid cells* have been met with. Dr. Knapp ("Trans. Fifth Internat. Oph. Cong.") reports one in which the wall felt so dense that he took it for an exostosis and proceeded to remove it, when the chisel pierced a bony shell, and a quantity of muco-purulent discharge escaped.

I know of no case of fluid accumulation in the *sphenoidal sinus*, though there seems to be no reason why it should not occur, except that the position of this cavity renders it less exposed than the others to causes of inflammation.

Cysts, polypi, or solid tumors of any of these cavities, or of the nares, may press upon the walls of the orbit or destroy them and extend into its cavity. A discussion of all of these diseases would lead into too wide a field for the limits of this article, and the reader must be referred to works on general surgery and to the elaborate chapter on this subject in Mackenzie's treatise on "Diseases of the Eye." Intracranial growths sometimes involve the roof of the orbit, and in chronic hydrocephalus its cavity is narrowed by pressure, and the eyeball is pushed forward.

George C. Harlan.

ORKNEY SPRINGS. *Location*, Shenandoah County, Va.; *Post-office*, during the season, from May 1st to December 1st, Orkney Springs; for remaining portion of the year, Mount Jackson, Shenandoah County.

Access.—To Mount Jackson, a station on the Harper's Ferry & Valley Branch of the Baltimore & Ohio Railroad, thence ten miles by conveyance to the Springs.

Analysis.—One pint contains:

	Healing Spring, 58.6° F. T.W. Mallet.	Powder Spring, 59.7° F. T.W. Mallet.	Bear Wallow Spring, 58.6° F. T. W. Mallet.
	Grains.	Grains.	Grains.
Carbonate of soda	0.002	0.406	.....
Carbonate of magnesia	0.141	0.369	.....
Carbonate of iron	0.058	0.027	.....
Carbonate of manganese	0.001	0.002	.....
Carbonate of lime	1.033	0.477	.....
Chloride of potassium	0.004	0.003	0.008
Chloride of sodium	0.015	0.044	0.011
Sulphate of potassa	0.023	0.020	0.026
Sulphate of magnesia	.....	.....	0.305
Sulphate of alumina	0.004	0.002	0.007
Sulphate of iron	.....	.....	0.567
Sulphate of manganese	.....	.....	.....
Sulphate of lime	0.143	0.219	0.089
Sulphate of lithia	.....	.....	0.008
Phosphate of lime	0.002	trace	0.001
Sulphide of sodium	.....	0.055	.....
Sulphuric acid	.....	.....	0.044
Silica	0.104	0.173	0.192
Organic matter	.....	trace	0.008
Total	1.530	1.797	1.266
Gases.	Cub. in.	Cub. in.	Cub. in.
Carbonic acid	0.48	0.89	0.60
Sulphuretted hydrogen	.....	0.61	.....
Oxygen	0.17	.....	0.05
Nitrogen	0.31	0.29	0.15

Therapeutic Properties.—The principal, or "Bear Wallow," spring is aperient, diuretic, and tonic. It is particularly valuable in dyspepsia, rheumatism, gout, affections of the urinary organs, and many female disorders. The "Healing Spring" (calcic) is alterative and tonic, and is employed in scrofula, malaria, syphilis, chronic ulcers, etc. The sulphur, or "Powder Spring," is used with success in diseases of the skin, liver, joints, etc. Another, the "Chalybeate," also containing sulphur, has proved efficient in anæmia, chlorosis, and neuralgia.

Climate.—Temperature rarely reaches 80° F. during the hottest days. Atmosphere is dry and bracing at all times.

This watering-place is situated on a plateau of the North Mountain, twenty-one hundred feet above tidewater. The geological formation, a shale, insures good and rapid drainage. The hotels, of which there are several, and numerous cottages, afford first-class accommodations for eight hundred people. Mountain scenery, walking, riding, hunting, and fishing, bowling, billiards, and a beautiful shaded lawn, furnish ample facilities for amusement to the guests. There are churches of the various denominations at Mount Jackson. The ordinary drinking-water is limestone and freestone.

George B. Fowler.

ORRIS ROOT (*Rhizoma Iridis*, Ph. G.; *Iris de Florence*, Codex Med.). The rhizomes of three or more species of *Iris* cultivated for this object in the south of Europe, especially in the vicinity of Florence, are the sources of this article. They, and a few other species, also, are familiar garden flowers both there and in this country, and are easily recognized by their thick, fleshy rhizomes, running along just beneath, or at the surface of, the ground, their vertical, equitant, linear, or sword-shaped, often curved or oblique leaves, and their large, showy flowers, with three spreading or drooping and three ascending and incurved perianth-divisions. The flowers are sometimes solitary and low (*I. pumila* Linn.), but generally several are borne in succession on a tall, branching scape. The three following are officially recognized as the sources of "Orris": *I. florentina* Linn., with very sweet-scented, white, or pale slaty-blue flowers; *I. germanica* Linn., with dark, violet flowers; and *I. pal-*

lida Lamk., with light blue, very large, and fragrant ones. They all resemble each other in most important particulars, and it is doubtful if they are entitled to full specific distinction. The former is a native of the southern and eastern Black Sea regions, the others of Europe; all have been cultivated for a long time.

The rhizomes are gathered in the latter part of summer, trimmed and peeled, and then dried in the sun, and afterward separated into qualities, according to size, symmetry, and appearance. The pieces are more or less long and flattened, with rounded surfaces and ends, often curved or twisted in drying, of a nearly white color, and compact but brittle texture. The scars where the rootlets have been cut away may be seen on the lower surface. Taste bitterish, slightly aromatic, and sharp. Odor,

Fig. 2646.—Orris Root and Leaves. (Baillon.)

for which it is valued, mild and pleasant, recalling that of violets. Orris which has been kept for one or two years is more fragrant than that just dried. This product has been for centuries used as a perfume, and less generally as a medicine, and is mentioned by most of the classical writers upon medicine. It yields, upon distillation, a minute quantity, 0.12 per cent., of a fragrant crystalline substance, generally known as *Orris camphor*, but really, according to Flückiger, consisting of *myristic acid*, impregnated with a little *essential oil*. Orris contains also a little *resin* and a very little *tannin*. *Starch* is abundant.

Action and Use.—Internally given, Orris, like our Blue Flag (*Iris versicolor* Linn.), is a cathartic and occasional emetic, but it is almost never employed in this way. It is a common ingredient of tooth powders, as well as of sachet powders (violet), and is otherwise used as a perfume. Large, fine pieces are now and then given to teething children to chew upon, but the practice is not to be commended.

Allied Plants.—A number of other species as well as the above are cultivated as garden flowers, under the name *Fleur de lis*, or Flower de Luce. The genera *Crocus* and *Gladiolus* furnish also a number of beautiful ornamental plants (see Flag, Blue).

Allied Substances.—Vanilla, Tonka, Heliotrope, and the essential oils in general. *W. P. Bolles.*

ORTHOPEDIC SURGERY. There remain still a few practitioners who deny the right of existence to specialties in medicine or surgery. The time for discussing such questions has, however, long since passed. The progress of medicine is marked by the development of separate branches, and as a community becomes more civilized, the line between these branches is still more sharply drawn. For at least one hundred and fifty years the term orthopedic surgery has been in use, yet the boundary lines of the specialty have not always been well defined.

Definition.—From two Greek words—ὀρθός, παιδεία—M. Andry formed *orthopédie*, to express, in a single term, the plan of his work ("Orthopédie," 1741), which was to teach different methods of preventing and correcting bodily deformities. Inasmuch as children are the more frequently affected, the earlier writers did not often include adult patients in their practice. A more general definition would be, "that branch of surgery which has to do with preventing and correcting deformity." Some have made *mechanical* synonymous with *orthopedic* surgery, and hence they consider it sufficient only to be a good instrument-maker or a good mechanician. If we thus limit the definition, it seems humiliating to the art of surgery to couple it with orthopedics. Andry never intended to limit this specialty to the one means of correcting deformities solely by mechanical appliances.

If the skilful diagnostician can recognize a disease whose natural progress is toward deformity, and can arrest the disease by the judicious use of drugs, or even simpler means, he practices orthopedic surgery. In a word, then, we understand that the orthopedic surgeon must have skill as a diagnostician, must make himself familiar with the clinical histories of diseases that lead to deformity, and must be expert in operating as well as in devising and adapting apparatus that will prevent as well as correct deformity.

Naturally the scope of orthopedic encroaches upon that of general surgery, as do all the specialties in which any surgical procedure is demanded. To define the scope of this branch of surgery is not so easy, therefore, as to define the terms employed.

The deformities that find a place in orthopedic treatises are those of the neck—the different varieties of torticollis, whether congenital or acquired; luxation and sub-luxation of the different joints, so frequently the result of disease of the articular ends of the bones; web hand and web-foot, irrespective of cause; club-foot, with its different varieties, and the deformities of the toes. Included in this list should be curvature of the spine, deformities of the hands and fingers, such as drop-wrist, Dupuytren's contraction and contraction of the tendons that results from paralysis; the deformities of the lower extremities that result from disease of joints, bones, and nervous system. Nearly all the deformities that are dependent upon rachitis are also included.

As other specialties become better developed, the deformities that pertain to the diseases included in their categories gradually drift away from the orthopedic and the general surgeon. Thus strabismus, hare-lip, deformities of the jaw and the teeth, as well as hernia, now belong to separate specialties. It is difficult sometimes to dissociate orthopedic surgery from neurology. The above list is not by any means complete, yet serves as a classification of the deformities that fall within the scope of the

specialty now considered. English and continental surgeons seldom include diseases of the joints in works on

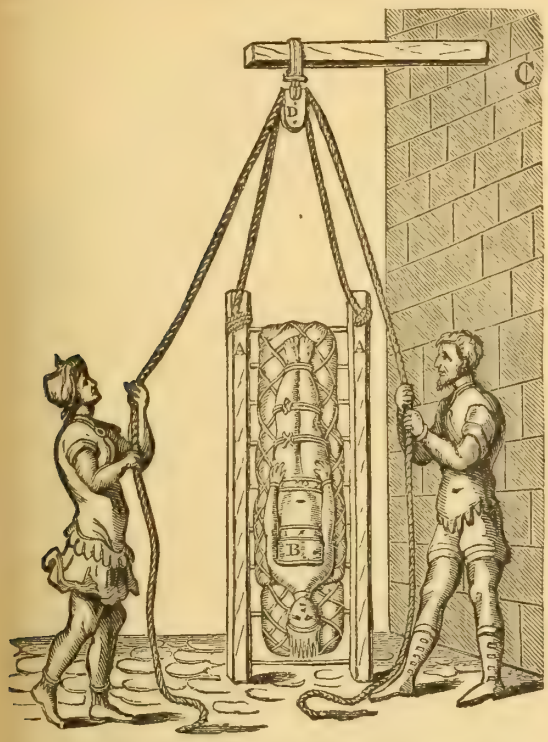


Fig. 2647.—Treatment of Spinal Disease by Succussion.

orthopedic surgery, but rather include more of those deformities that really belong to other branches of medicine. No treatise in America, however, is considered complete

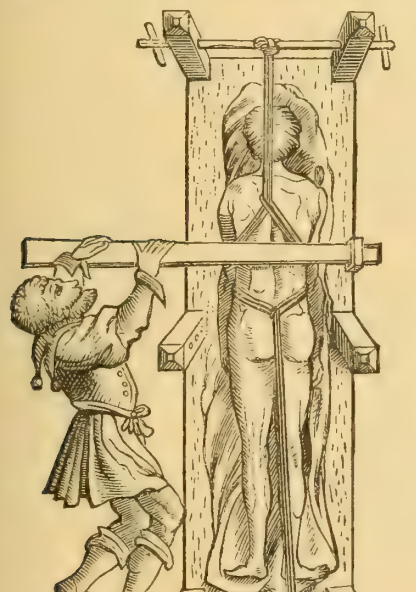


Fig. 2648.—Treatment of Gibbosity in Pott's Disease, as practised in the Days of Hippocrates.

without a pretty full discussion of diseases of the joints, and especially of their treatment by mechanical means.

History.—About the year 400 B.C., Hippocrates, in a work on the Articulations, gives us the first insight into

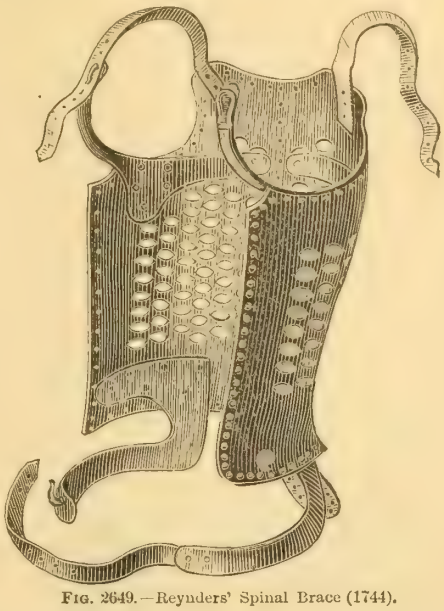


Fig. 2649.—Reynders' Spinal Brace (1744).

the treatment of deformities. The descriptions given by this early author were very full, and to him we are indebted for many terms now employed; for instance, he divided spinal curvature into *cyphosis*, *lordosis*, and *skoliosis*. To make this chapter more intelligent, it is better to follow the history of the pathology and treatment of deformities in the different regions of the body.

The Spine. — Among the earliest methods of treating spinal disease is one known as succussion. This is mentioned by Hippocrates as a popular method in his day, and one which this great man condemned. He observes that he was "ashamed to treat all such cases in this way, because such modes of procedure are generally the work of charlatans." Fig. 2647 illustrates this method. Full directions are given by Hippocrates for practising succussion. The ancient treatment of gibbosity is shown in Fig. 2648.

In 1650 the second book of the works of Ambroise Paré, "De Gibborum Corrigenda Deformitatum," was published, and in this work we find recommended for spinal disease two plates of iron, a posterior and an anterior one, fastened together in the form of a cross. It is similar to the brace shown in Fig. 2649. Full instructions are given for changing the apparatus every three months, if necessary, according to the age and rapidity of growth. As Biggs remarks, "Paré's

Fig. 2650.—Nuck's Spinal Brace.

corset is the earliest splint intended to be worn for diseased spine."

In 1650 Glisson published a work, "De Rachitide," translated by Culpepper, in which is described a method of treating the distorted spine by suspension. The weight of the body sufficed usually to make the necessary extension, yet occasionally heavy substances were attached to the feet. As a record, simply, of the earliest method of treating spinal diseases by suspension, it may be interesting to give the following quotation from Biggs: "Swathing bands, first crossing the breast and coming under the arm-pits, then about the head and under the chin, and receiving the hands by two handles, so that it is a pleasure to see the child hanging pendulous in the air, and moved to and fro by the spectators." In this same work Glisson describes a method of making corsets by means of whalebones sewed into the cloth, and insists particularly on getting a good fit.

Fig. 2651. — Little's Spinal Brace.

In 1656 Scultetus described the "torquen" of Oribasius, which had been used for many years in the treatment of spinal deformities. From the description given this appears to be essentially the same as the apparatus shown in Fig. 2648.

In 1739 Heister described and recommended a T-shaped splint of steel. Neck-, shoulder-, and pelvic-straps were employed to retain it in position.

Mr. John Reynders, the veteran instrument-maker, of this city, tells me that one of his ancestors, Reinder Reynders, as long ago as 1740 was engaged in the manufacture of orthopedic instruments. He has shown me a drawing of a very interesting spinal brace made in 1744, or earlier. (See Fig. 2649.) It is made of copper, has axillary pieces with shoulder-straps, a pelvic band, and is in many respects similar to the one employed by Ambroise Paré. Mr. Reynders has also shown me an old note-book possessed by his ancestor, whose son was a physician in charge of an orthopedic hospital in Groningen, Holland.

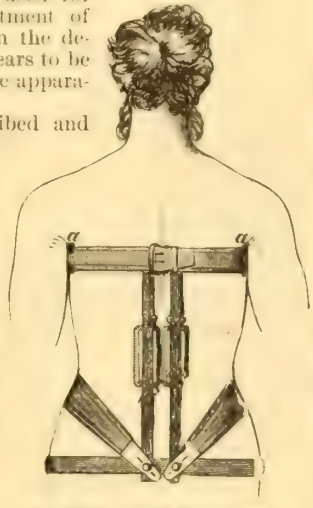


Fig. 2652. Davis' Spinal Brace.

Fig. 2653. — Original Taylor Brace.

In 1741 Andry's great work on "Orthopédie" was published, and this practically marks the birth of the specialty. The mechanical treatment of spinal deformities was not materially advanced by this publication, although, it is true, he recommends a chin-rest for the head when it is bent forward.

In 1799 appeared the works of Percival Pott, of London, and of M. David, of Rouen, both of which contained important contributions to this subject. Pott wrote upon that kind of palsy which accompanied curvature of the spine, and David upon the effects of rest and movement. That David entertained correct notions of the pathology of the disease the following will testify: "As for the bones which are primarily affected, they are no sooner relieved of the débris than they begin to resume their solidity, and if several vertebræ have participated in the disease, they form themselves into one common mass of ossification, thus terminating this *grand cure*, which, as we see, must be the *work of nature*, *of time*, and of *repos*." ("Dissertation sur les Effets du Mouvement et du Repos dans les Maladies chirurgicales," 1779).

Fig. 2654.—The same with chin-piece.

In 1772 M. LeVacher de la Feutrie published his "Traité du Rakitis," and in this volume we find pictured a spinal brace with a head-spring, even at that time an old apparatus, which had been devised by Antoine Nuck, a German physician, who died in the latter part of the seventeenth century. This apparatus is described on pages 306 to 309 of LeVacher's work, and is shown in Fig. 2650. It consisted of a corsage strongly bound with whalebone and carrying a staff in a metal socket. This mode of treatment at one time was quite popular, and was introduced into England by a surgeon named Reed.

In 1794 Schmidt, of Marburg, devised an instrument whereby the weight of the upper part of the trunk was partially supported. This instrument serves as the foundation for most of the apparatus of the present day. Metal bands encircled the trunk, and rested upon the iliac crests. It carried two metal rods, passing one on each side of the body, and terminating in curved handles beneath the arms. A plate passing across the shoulders steadied the upper extremities of the rods. In addition to this certain spring pads could be attached along the vertical portion, so as to press on the convex portion of the spine.

Fig. 2655. – Banning's Uterine Supporter.

In 1796 Darwin, in his work on "Zoonomia," vol. ii., page 87, endeavors to illustrate the value of recumbency in the treatment of spinal curvature, and describes two machines which he had invented, one for the sitting posture and the other for the recumbent. The mechanical couches in use from that day to the present are modifications of Darwin's inclined plane. His couch was pro

Fig. 2656.—Banning's Uterine Supporter and Spinal Brace combined.

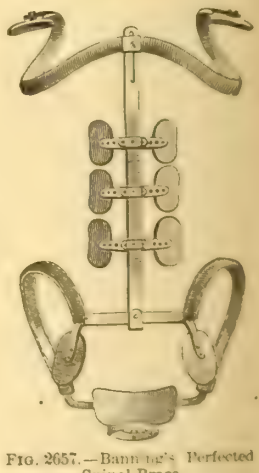


Fig. 2657.—Banning's Perfected Spinal Brace.

vided with means for making traction on the head. The present century has been rich in the production of spinal apparatus, and yet the improvements on the splints of the last century, when submitted to a critical examination, are not remarkably striking.

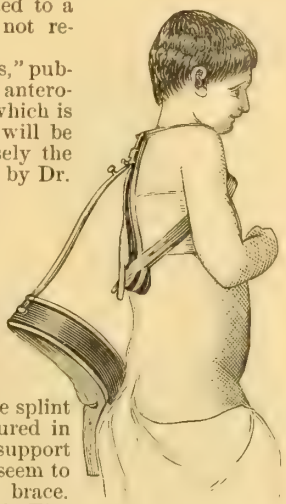


FIG. 2658. — Stillman's Spinal Brace.

In Little "On Deformities," published in 1853, is figured an antero-posterior spinal support, which is shown in Fig. 2651, and will be seen to resemble very closely the system of braces employed by Dr. Henry Davis, formerly of this city, and subsequently improved by Dr. C. Fayette Taylor.

In the year 1852 Dr. Henry G. Davis published in the *Boston Medical and Surgical Journal* an account of an apparatus which he had already employed for three years. The splint is only described, not figured in this article, and hence the support shown in Fig. 2651 would seem to antedate the Davis-Taylor brace. The Davis splint is shown in Fig. 2652. The object of the inventor was to throw the weight of the trunk upon the oblique processes, which were to act as fulcrums for tilting or rotating the vertebræ. The principle, then, was hyperextension of the spine, and this is the object generally sought in all the modifications of this apparatus. C. F. Taylor published an account of his apparatus in the "Transactions of the New York State Medical Society," 1853. The original Taylor brace is show in Fig. 2653, but the improvements upon this original design have been so great that one would scarcely recognize the Taylor brace of to-day. In Fig. 2654 will be seen the chin-piece which is so popular at the present day.

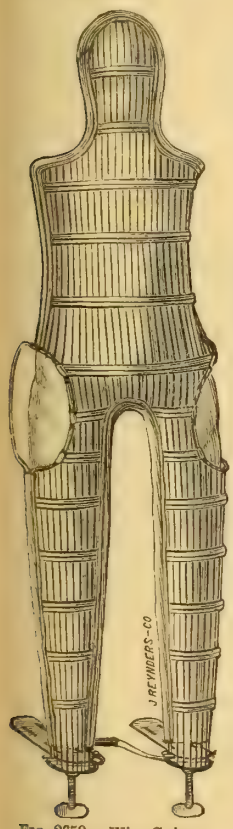


FIG. 2659.—Wire Cuirass.

In 1868 Banning, of New York, published a system of mechanical therapeutics, based upon his uterine supporter, which is shown in Fig. 2655. The next step in the evolution of this apparatus is shown in Fig. 2656. The apparatus, as completed, is shown in Fig. 2657. The pads over the hips are at present used in the Taylor brace. Dr. Stillman, of this city, has a brace embodying principles similar to some previously mentioned. The advantage, he claims, is backward traction. This is shown in Fig. 2658. The apparatus employed by Mr. Chance, of London, is similar in construction to the Davis brace. The same may be said of the Andrews and of the Washburn splints. The wire cuirass, slightly modified from Bonnet, is shown in Fig. 2659. It always has an important place in orthopedic surgery, and is similar to the cuirass used by Ambroise Paré.

In Fig. 2660 is seen a spinal brace which has been used by Dr. Knight, of the Hospital for the Ruptured and Crippled, for the last thirty years. It consists of a simple framework of steel, with canvas fronts, and is intended to give lateral as well as antero-posterior support.

This brings us to the period of plastic apparatus, and the chief is the plaster-of-Paris jacket. In the summer of 1874 Dr. Joseph Bryan, now of Lexington, Ky., applied the first plaster-of-Paris jacket, on a female patient, in the wards of Bellevue Hospital. Dr. Bryan was at that time an interne of the hospital. Mention was made of this fact in the *New York Medical Journal* for December, 1874, p. 627, under the heading, "Notes of Hospital Practice in Bellevue Hospital." Dr. John J. Reid, of this city, was the reporter, and from these notes the following extracts are taken: "This method of treating injuries of the spine, as well as caries of the spine (the plaster-of-Plaster bandage) has been introduced into the hospital by Dr. J. Bryan, and so far has yielded excellent results, especially in Pott's disease."

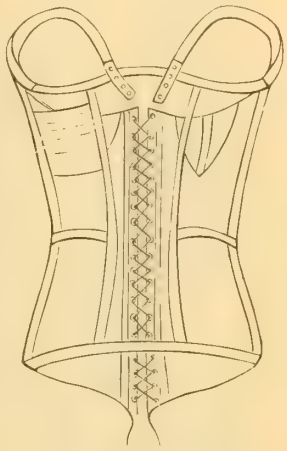


FIG. 2660.—Knight's Spinal Support. Posterior view.

The next paragraph describes the method.

Again, in the *New York Medical Journal* for April, 1875, p. 407, the same reporter, under "Notes of Hospital Practice," with the heading, "Plaster-of-Paris Splint for Caries of the Spine," gives the following information: "The splint referred to in the *Journal* for December, 1874, p. 627, proves of great value in those cases of disease of the spine in the lower dorsal and lumbar regions. It can be made lighter than mentioned previously, by covering the skin with a tight-fitting undershirt, and then carrying the rolls of plaster around the body, from axilla to the pelvis."

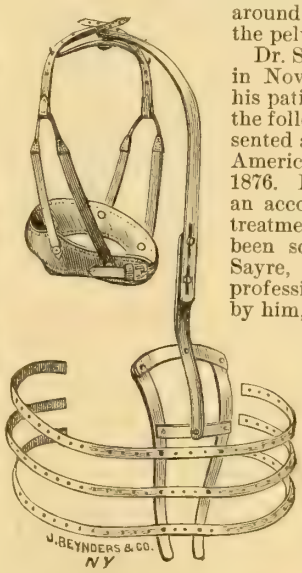


FIG. 2661.—The Jury-mast.

Dr. Sayre applied his first jacket in November, 1874, and showed his patient at his Bellevue Clinic the following February. He presented a report of his cases to the American Medical Association in 1876. Dr. Bryan never published an account of his work, and the treatment by this method has been so fully carried out by Dr. Sayre, and brought before the profession in so zealous a manner by him, that his name has become inseparably associated with the plaster-of-Paris jacket. To the genius of this distinguished surgeon, therefore, we are indebted for whatever good has resulted from this far-famed treatment.

From 1874 up to the present time the plaster-jacket has been tested more or less thoroughly throughout the civilized world. The jury-mast, as it is called by Dr. Sayre, is practically the same apparatus that Nuck used in the seventeenth century (see Fig. 2650). It is adapted, however, for the plaster-jacket, and is shown in Figs. 2661 and 2662, taken from one of Dr. Sayre's latest publications. The great principle on which this method is based is that of fixation, so that the solid jacket is employed in all cases in which there is any

active disease. The perfected jacket, for convalescent cases, is known as the plaster corset (Fig. 2663). Since the introduction of this method of treatment many substitutes have been devised, on the score of improvement, by surgeons in this country and abroad.

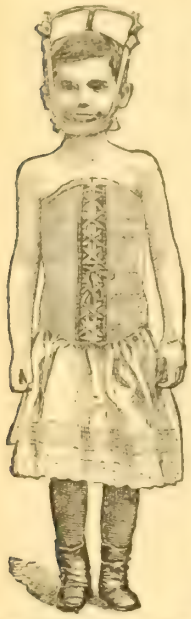


Fig. 2662.—Sayre's Plaster-jacket and Jury-mast applied.

In 1879 Dr. Ap M. Vance, of Louisville, Ky., published an account of a removable paper brace, made by means of Manilla paper and glue, over a plaster cast. In England poro-plastic felt has been largely substituted for plaster. In young children Dr. Sayre has been in the habit of using the cuirass of Bonnet, with head spring attachment.

The method of exerting continuous traction in spinal caries, by means of portable apparatus, so far as I am able to learn, was first employed by Dr. Edmund Andrews, of Chicago, and a description of it was published in the *Chicago Medical Examiner*, September, 1863. The apparatus consisted of three pieces, made over the cast of the body; the upper and lower portions were lined with adhesive plaster, so that the traction could be made by means of the steel rods front and back. Continuous extension in the recumbent position was employed by Buckminster Brown, of Boston, in 1864, and from this author we learn that E. W. Tuson, in 1841, and Samuel Hare, of London, in 1849, employed extension.

In 1878 Dr. Charles F. Stillman, of this city, published in Tiemann's catalogue an account of an apparatus embodying the same principles, but the zones were secured to the body by a plaster-of-Paris bandage. This is shown in Fig. 2664.

On January 27, 1879, Dr. John A. Wyeth, of this city, published a paper on the treatment of spinal curvature by continuous extension, and his apparatus is shown in Fig. 2665.

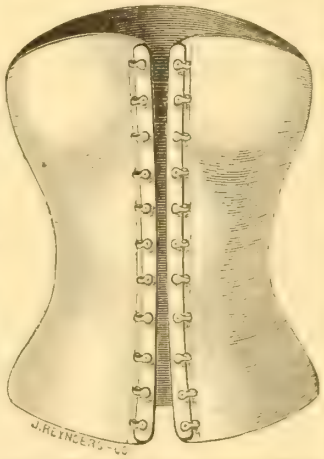


Fig. 2663. — Perfected Plaster-of-Paris Corset.

Dr. M. J. Roberts, of this city, has devised a brace of two plaster zones, connected by spiral rods, placed laterally and posteriorly. The improved apparatus, to be used without the plaster-of-Paris, is shown in Fig. 2666.

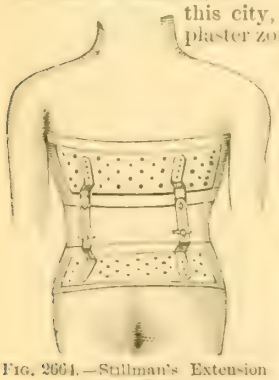


Fig. 2664.—Stillman's Extension Spinal Brace.

The general manner of applying the jacket has changed very little since its introduction. The patient is partially suspended by the hands and arms, just as in the days of Glisson. Occasionally an accident is met with, by negligence or otherwise, and this has led Mr. Davy, of England, to introduce the hammock as a substitute. (See article Hammock Suspension.)

So much for the mechanical treatment of Pott's disease. The history would be incomplete without some reference to the pathology in the light of recent investigations. From the earliest times the disease has been regarded as of strumous or scrofulous origin, although there have been some notable exceptions. At the present day the disease is regarded as tuberculous in character, and this is but a return to the teaching of Nélaton, fifty years ago. The late Professor Gross was an advocate of this theory, and while the arguments were based upon the clinical history, it remained for modern researches in pathology to demonstrate, in the field of the microscope, the real nature of the disease.

Fig. 2665.—Wyeth's Extension Spinal Brace.

The management of abscesses has undergone really little change. Orthopedic surgeons, as a rule, have always regarded these collections of pus as a *nodi ne tangere*, while general surgeons have nearly always applied the general rule that relates to pus wherever and whenever found.

A history of spinal disease would be incomplete without a mention of osteotomy and excision. J. and E. Boeckel, in Germany, Israel and Reclus, in France, removed necrotic bone of the vertebræ through an opening made into a psoas abscess in the loin. Mr. Treves, of London, and Mr. Chiene, of Edinburgh, have both operated in this way. The results hardly justify any extended reference, because, as Mr. Reves, in his work on "Bodily Deformities," published in 1885, remarks, the method "is yet quite young, and on its trial."

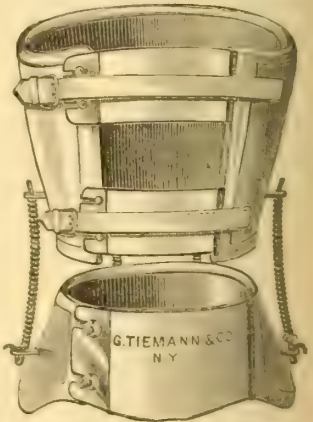
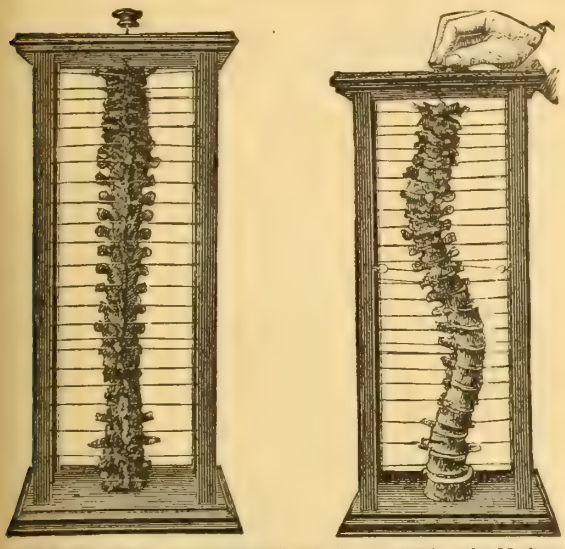


Fig. 2666.—Roberts' Extension Spinal Brace.

Lateral Curvature of the Spine.—The history of this deformity consists chiefly of the various theories as to causation. The first mention of rotation was in the year 1710, when M. Le Clerc, in a work entitled "The Compleat Surgeon," makes the following statement: "There are others also, wherein the vertebræ not only grow contorted on the Ribs, but turn in a manner a little round on themselves; and there is something in this Sort of Deformity that requires particularly to be observed, and that is, that the oblique Apophyses (articular processes) of the convex side draw close to the concave side."

Andrew Dods, of London, in 1824, published his "Observations on the Rotated or Contorted Spine, commonly called Lateral Curvature." He was followed by Bampfield, John Shaw, and others, all of whom confirmed this fact, now so well established. To give the names of the various authors who have advanced theories on the etiology would be tedious in the extreme. Two names, however, must figure largely in the present history.

Charles H. Rogers-Harrison, in 1824 ("Deformities of the Spine and Chest"), propounded a theory to account



FIGS. 2667 and 2668.—Judson's Device for Demonstrating the Mechanism of Rotation in Lateral Curvature of the Spine.

for the rotation of the spine. The following quotation (pp. 93, 94) is given in full, because of the difficulty of paraphrasing: "To conceive the cause of this extraordinary derangement, it is necessary to imagine that, in a well-marked curvature of the spinal column continuing to sustain the weight of the body, the vertebræ of the middle of that curvature are, in fact, in the same situation as if they were urged by a direct and horizontal force on the side of the concavity towards that of the convexity. In this impulsion the body of the vertebra, isolated in its anterior and lateral parts, experiences no resistance; but the articular processes are powerfully restrained by their reciprocal connection. The transverse processes find in their articulation with the tuberosities of the ribs a resistance to their deviation which would be very weak on the part of an isolated rib, but which becomes considerable by its union with the adjoining ribs. It results from this exposition that behind the central part of the dorsal column there is efficacious resistance to its lateral displacement; that before this central part there is no resistance to that displacement, and, consequently, the vertebra must necessarily turn on its axis to arrive at the position which observation so frequently presents."

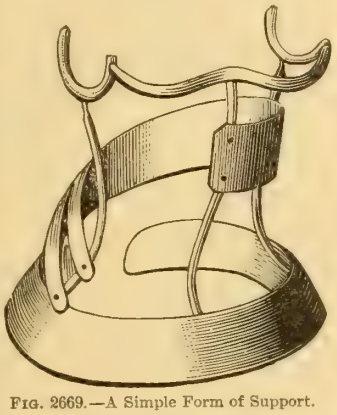


FIG. 2669.—A Simple Form of Support.

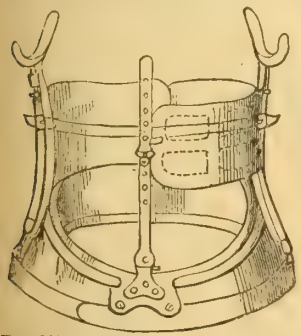


FIG. 2670.—The Eagland Support modified.

This same theory was worked out by Dr. A. B. Judson and presented to the New York Academy of Medicine, April 6, 1876. He knew nothing of Rogers-Harrison's theory, and the conclusions he reached are almost identical with those published in 1824. A very ingenious contrivance for demonstrating this theory was devised by

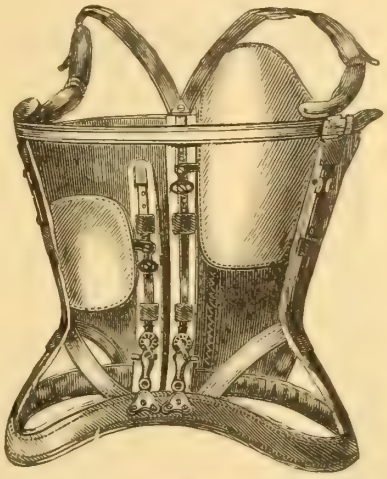


FIG. 2671.—Lateral Curvature Brace.

Dr. Judson, and is shown in Figs. 2667 and 2668. The theory propounded by Professor Hermann Meyer, of Zurich ("Archiv. klin. Med.," xxxv., 1866), is an ingenious one, but does not satisfactorily explain the cause of rotation.

Writers upon this subject have been divided in their therapeutics. One class employs gymnastics, to the exclusion of the other forms of treatment, another class relies upon apparatus alone, while a third class employs both gymnastics and apparatus. Mr. William Adams, of London, has contributed largely to the literature of this subject, and the second edition of his lectures, published in 1882, makes a volume of nearly three hundred pages, in which the various causes, and the pathology and treatment, are fully described.

The different forms of apparatus include what is known as the Eagland spinal support, improved by Mr. Adams, and shown in Fig. 2670; the plaster-corset, a fair illustration of which is shown in Fig. 2663. Among others is the poro-plastic felt jacket, a very simple brace, with pads over the projecting ribs, shown in Fig. 2669, and a rather complicated apparatus which is shown in Fig. 2671. Dr. Shaffer, of New York, uses a brace, the object of which is to act as manual force would act in untwisting the spine. The plaster-of-Paris corset, applied when the patient is fully extended, is the outgrowth of the plaster-jacket for Pott's disease. The Darwin couch and many forms of apparatus have been alluded to already. In Fig. 2672 is shown a plan of treatment that is advo-

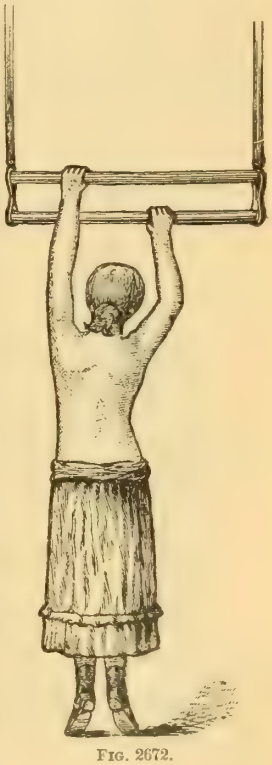


FIG. 2672.

cated by Dr. Benjamin Lee, of Philadelphia, and another method, pictured in Fig. 2673, is also used as a means of extending the spine, by acting upon certain groups of muscles. The mode of self-suspension by the swing, as

Fig. 2673.

employed by Dr. Sayre, of New York, is shown in Fig. 2674. Varies modes of gymnastics are employed, and this treatment, which is growing in popularity now, is the system of gymnastics, after Ling, of Sweden, and advocated more extensively by Roth, of London. Dr. Jules Guérin, who was an advocate of the muscular theory, published a memoir, in 1840, in which he advised division of the spinal muscles. The cases which he treated, however, and reported, were subsequently shown, by a committee appointed for investigation, to have made no improvement whatever. Dr. Samuel Ketch, of New York, in January, 1886, presented an important paper to the Orthopedic Section of the Academy of Medicine, showing the frequency of lateral curvature in young children.

Fig. 2674.

The whole history, then, of lateral curvature, is marked by the development of theories as to its cause, the influence of school and vocation, the extraordinary claims made for gymnastics, and the modifications of braces, the principles of which are chiefly pressure against projecting parts of the body. Those who have been most conspicuous in the treatment by spinal extension are LeVacher and Glisson, Benjamin Lee, Louis A. Sayre, and the late J. K. Mitchel.

Head and Neck.—The appliances used for deformities in this region, which really belong to spinal deformities, are very ancient in origin. Exception must be taken, of course, to torticollis, which is usually not dependent upon vertebral disease, but inasmuch as the apparatus employed for this deformity is similar to that used for disease of the cervical vertebræ, it will only be necessary to present some of the devices employed for torticollis. Reference must be made, of course, to the Nuck head-spring described by LeVacher in 1772 (see Fig. 2650). Sheldrake, of London, published, in 1782, a description of an apparatus in many respects like Nuck's.

Fig. 2675.—Wood's Apparatus for Wry-neck.

The late James R. Wood employed an elastic spring for wry-neck, which is shown in Fig. 2675. The apparatus devised by Henry G. Davis for wry-neck, shown in Fig. 2676, resembles very much some of the old forms of head supporters found in the old English text books. Dr. Shaffer has modified the chin piece (Fig. 2677), so that it forms a very useful apparatus for the treatment of wry-neck. In Fig. 2678 is shown a very simple method of treating wry-neck, which consists of a rubber cord passing from a ring round the shoulder to the back part of a head-band. An apparatus which bears the name of Dr. Markoe, of this city, is shown in Fig. 2679.

Fig. 2676.—Davis' Apparatus for Wry-neck.

The Hip.—In the *American Journal of the Medical Sciences* for February, 1831, Dr. J. Randolph published an account of Dr. P. H. Physick's method of treating disease of the hip. From this paper the cut which is shown in Fig. 2680 is taken to illustrate the carved wood-splint employed by this surgeon. It will be seen that this is a fixation apparatus, and must be renewed from time to time as deformity becomes less marked. From this same paper we learn, through Dr. B. H. Coates, that Physick employed this splint in the Pennsylvania Hospital prior to 1830. Bonnet, in 1834, in his "Memoirs upon Fracture of the Femur," described "le grand appareil," and claimed for it, in 1845, the power of fixation in the treatment of disease of the hip

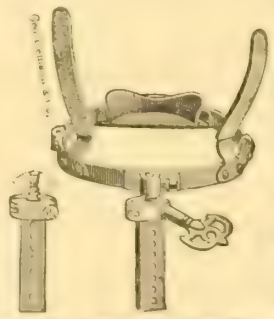


Fig. 2677.—Shaffer's Modified Chin-piece, for the Treatment of Torticollis and Pott's Disease in the Cervical Region.

This is substituted now in this country by what is known as the "wire cuirass." Decros, in the *Gazette des Hôpitaux* of June 30, 1835, published a case of hip disease in which traction was employed. This was in April of the same year, three or four months before the use of Harris's splint, which, from his paper in 1839, is shown to have been applied in July, 1835.

FIG. 2678.—Apparatus for the Treatment of Wry-neck.

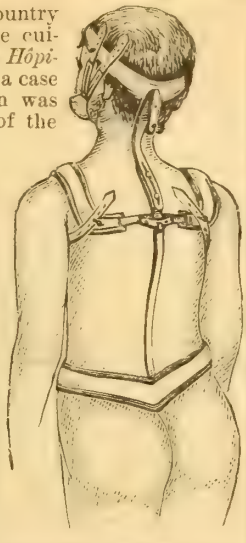


FIG. 2679.—Markoe's Torticollis Apparatus.

FIG. 2680.—Physick's Wooden Hip-splint.

In 1839 Dr. William Harris, of Philadelphia published a series of four cases in the *Medical Examiner*, January 19, in which he employed, in the treatment of this disease, traction and counter-traction, combined with Hagedorn's apparatus for fractured thigh. The first portable hip-splint to receive the weight of the body, on two perineal straps attached to a pelvic band, was devised by Ferdinand Martin, and is shown in Fig. 2681, taken from Bonnet's "Therapeutics of Articular Diseases," Paris, 1853, pp. 416, 417. Traction is made by a laced gaiter. A joint is found at the knee, and there is a mechanism for making abduction and rotation outward, as well as for producing extension as opposed to flexion.

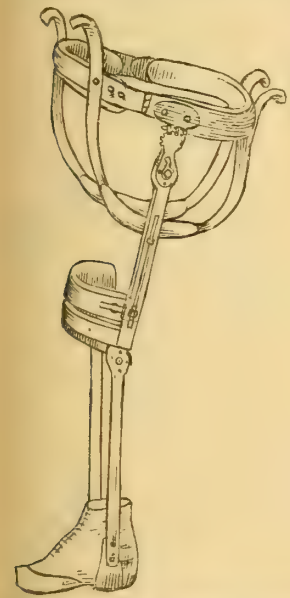


FIG. 2681.—Hip-splint devised by Ferdinand Martin. (From Bonnet.)

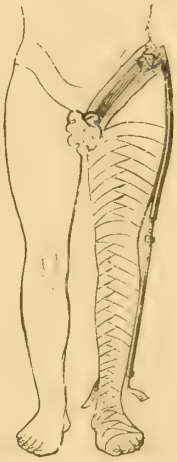


FIG. 2682.—The Davis Hip-splint.

In the *American Medical Monthly* for March, 1857, the first mention is made of comments on a splint devised by Dr. Henry G. Davis. In 1860 Dr. Davis published in this journal a paper giving in detail his method of treatment. Fig. 2682 represents his splint applied. Following this were papers by Drs. Alden March, of Albany, and C. F. Taylor, of New York. During the next decade numerous splints were devised, and bitter discussions were maintained, by men prominent in this specialty, as to the justice of their claims for invention. This portion of history is best passed over in silence. Fig. 2683 shows the Sayre short splint as originally employed. Andrews's ischiatic crutch is shown in Fig. 2684, Bauer's splint in Fig. 2685, Taylor's is shown in Fig. 2686, but it must be stated that this is Taylor's splint as known in the shops; it is the result of his early efforts in this direction, and many changes have since been made.

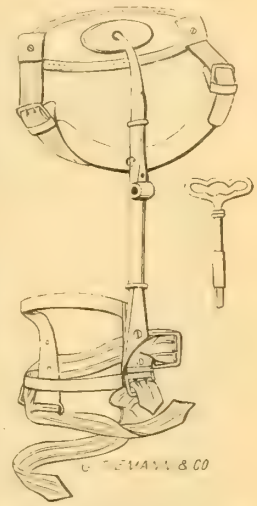


FIG. 2683.—Sayre's Short Hip-splint.

In April, 1867, Dr. Gurdon Buck described his extension apparatus for the treatment of fracture of the thigh. This, he stated, had been in use in the New York Hospital for six years prior to his publication. The apparatus (see Fig. 1060, in vol. ii.) is used while the patient is confined to bed. The Sayre long splint is really the Taylor splint, plus the abduction screw, which screw Taylor himself claims. A useful attachment, devised by Shaffer, is shown in Fig. 2687. The long splint combines, it is claimed, traction with motion, but it is really traction with fixation, inasmuch as few of the splints at present in use carry out the indications of the inventor.

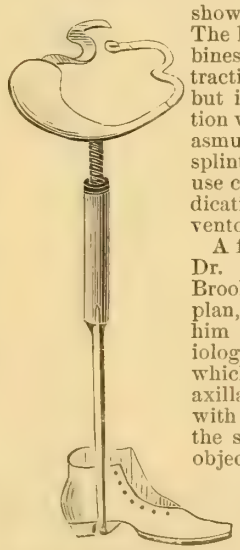


FIG. 2684.—Andrews's Ischiatic Crutch.

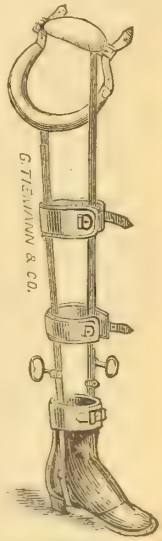


FIG. 2685. Bauer's Hip-splint.

A few years since, Dr. Hutchison, of Brooklyn, revived a plan, designated by him as the "physiological method," which consisted of axillary crutches, with a high shoe on the sound limb, the object being to secure extension of the limb by its own weight.

Fixation Apparatus. — Credit is due the French surgeon Bonnet, of Lyons, whose "grand appareil" forms the basis of what is known as the "wire breeches," and other forms of apparatus used after operative procedures. Mr. Bryant, of Guy's Hospital, London, has devised and published in the *Lancet* (1881, vol.

i., p. 159) a splint for maintaining parallelism of the limbs (see Fig. 2688).

For many years a method of treatment, devised by Hugh Owen Thomas, of Liverpool, has been well known throughout Great Britain. It is shown in Fig. 2689, and consists, as will be seen, of axillary crutches, a bar of iron passing from the angle of the scapula down over the hip to the middle of the calf, terminating, above and below, in bands which nearly completely encircle the chest and calf, and fastened more securely to the thigh by another band riveted at a point just below the hips, and, finally, a patten or high shoe on the sound foot. This appliance aims to fix not only the hip but the joints immediately above and below this articulation, and is simply a fixation splint. The splint of E. J. Chance, as described by Noble Smith in his "Surgery of Deformities," in 1882, embraces the trunk, in its lower two-thirds, and the thigh (see Fig. 2690). The splint of Thomas, of Liverpool, is very much like that of Physick's, already described.

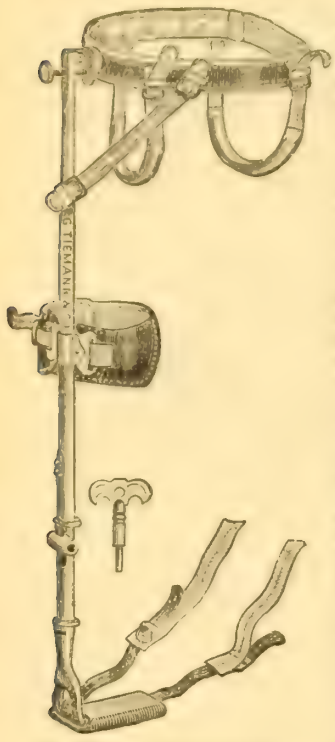


Fig. 2686.—Taylor's Hip-splint.

In a paper on the "Fixative Power of Traction," by Dr. A. B. Judson, of this city, it is claimed that one of the best means of securing fixation is by this very principle of traction. In this paper the history of fixation and traction is given, and the *rationale* of extension is fully explained. Dr. Judson has contributed a number of interesting papers bearing especially on the therapeutics of this disease, and has done more than any one of the present day to popularize the principle of fixation.

Fig. 2687.—Shaffer's Abduction Screw-attachment for the Hip-splint.

As to the pathology of the disease, views have differed; hence important changes in this history should be here recorded. During the early years of the extension treatment surgeons in general regarded hip-disease as dependent upon injury or traumatism, having for its lesion an inflammation of the ligaments and soft parts generally. Exception must be made to the above statement, so far as regards traumatism, since a majority of surgeons have always regarded the disease as strumous or scrofulous in character. Within recent years, however, a decided change has taken place, and the truth of the old theories held by Nélaton, Gross, and their contemporaries, to the effect that the disease was tubercular, has been demonstrated by researches both on the operating-table and in the dead-house. There are few now who do not regard the disease as a central bone-lesion from the beginning, and many look upon it as tubercular, although there are still some who are loath to accept the doctrine.

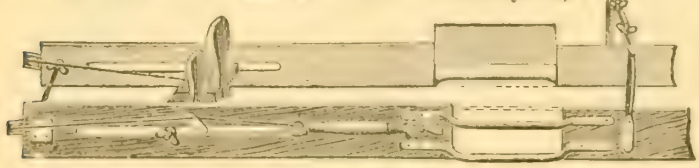


Fig. 2688.—Bryant's Apparatus for Maintaining Parallelism of the Limbs in Hip-joint Disease.

Fig. 2689.—Thomas's Fixation Splint for Hip Disease.

The treatment by operative procedures furnishes another epoch in the history of the disease, and the first recorded operation of excision of the joint was by Huson, of Dublin, Ireland, in 1829, the patient being a male adult. Sir Benjamin Brodie, in England, operated in 1836. The removal of the head of the bone was first suggested by Charles White in 1769. In Germany, R. Textor and M. Jaeger first operated. In France, in February, 1847, P. H. J. Roux was the first to perform the operation, on a male, fifteen years of age. In Scotland, Buchanan, of Glasgow, operated in December, 1850. In the United States, Dr. Oliver C. Wilcox, of Easton, Pa., operated for the first time, in 1849, on a patient thirty-five years of age. Dr. Bigelow, of Boston, operated in 1852, but to Dr. Lewis A. Sayre, of New York, is due the credit of having performed the greatest number of excisions.

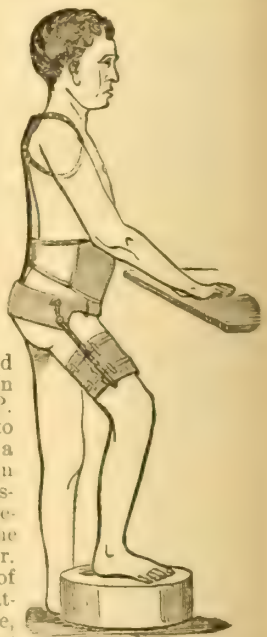


Fig. 2690.—Chance's Hip-splint.

The first excision really performed on the hip-joint for

deformity was by Anthony White, of London, in 1822. It has been claimed by some that simple extraction of loose bones from the hip-joint is excision. The first operation of this kind was performed by Dr. Schlichting, of Germany, in 1730. Dr. J. F. Minor, of Buffalo, N. Y., did this operation in the case of a fracture of the neck of the femur in 1782 (?).

For correcting the deformities which result from disease at the hip the first operation was performed by Dr. Reah Barton, of Philadelphia, in 1826; this consisted in a transverse section, by means of a saw, between the two trochanters; the result obtained was motion, which continued for a few years, but was followed by anchylosis. Dr. Lewis A. Sayre, of New York, did the next operation for this deformity in 1862, the operation consisting of a transverse section of the femur, elliptical in form, just above the trochanter minor. This surgeon operated again in 1862, and both of the cases are fully reported in Dr. Sayre's writings. Mr. Adams, of London, in 1865, made a subcutaneous division of the neck of the thigh-bone, for a vicious deformity of the right hip, in a patient aged twenty-four; this was followed by other English surgeons, such as Jessup, of Leeds; Jordan, of Birmingham; Jowers, of Brighton; and Craft, of London. Volkmann in 1873 performed a subtrochanteric osteotomy of the cuneiform variety. It consisted in removing a wedge-shaped piece of bone from the femur, just below the trochanter, the apex of the wedge bordering closely upon the inner side of the femur. Reeves, of London, in his work published in 1885 on "Practical Orthopedics," gives a diagram showing the operation he adopts, which is an incomplete infratrochanteric osteotomy. Gant, in the *Lancet* for December, 1872, published an account of a simple osteotomy below the trochanter minor. Dr. Stephen Smith, of this city, in 1883, published an account of a very ingenious operation below the trochanter minor, in which a half-tenon and mortise was made (see article Osteotomy).

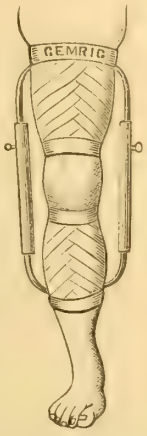


FIG. 2691.—Sayre's Knee-splint.

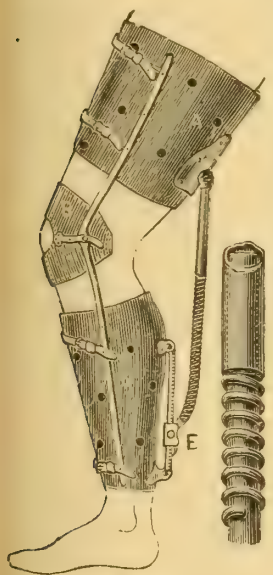


FIG. 2692.—An ordinary Form of Knee-splint for the Correction of the Deformity.

The operation of drilling the trochanter in order to reach the caseous foci of the epiphysis was first performed by Kirkpatrick, of Dublin, in 1867. His plan was to cut down upon the trochanter major, and tunnel into it with a trephine or drill. Mr. J. Gregg Smith, fourteen years later, described a procedure which is the same as that employed by Kirkpatrick, except that Kirkpatrick used potassa cum calce, and Smith used the Volkmann spoon or scoop. The operation was employed by Mr. Macnamara about the same time that Mr. Smith operated on his case, and in recent years by Mr. Stoker, of Dublin, and Sir William Stokes, of the same city.

THE KNEE.—In studying the history of this particular branch of orthopedic surgery one finds it difficult to note the dates of special advances. Before the days of traction in joint-disease fixation splints were employed, and these date from the earliest period of medicine.

The pathology of "white swelling" is better understood, and we now speak more freely of tuberculous ostitis of the knee than we do of tuberculous coxitis.

The treatment of knee-joint disease, and of the deformities resulting therefrom, presents nothing eventful

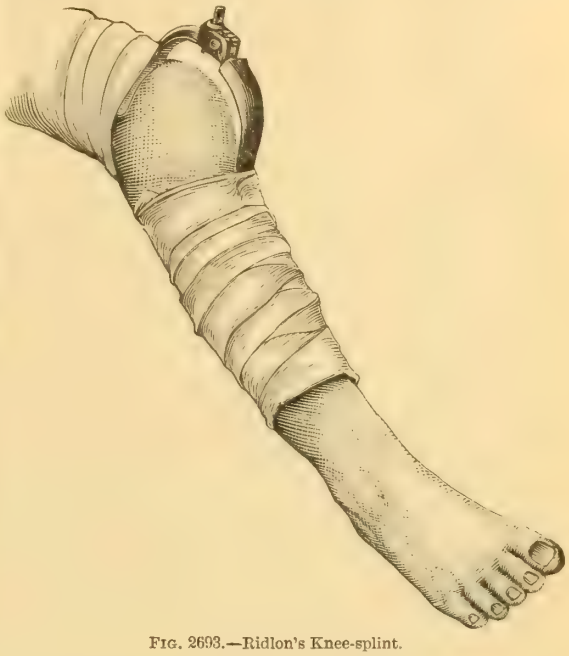


FIG. 2693.—Ridlon's Knee-splint.

in a historical way. Extension and fixation splints have been in use for many years; most of these consist of thigh- and calf-bands, with bars on either side connecting the two; these bars are divided and made extensible when it is desired to obtain traction; this is notably a feature in what is known as the Sayre splint (Fig. 2691). A common apparatus of the shops, shown in Fig. 2692, consists of thigh and calf-pads connected by an endless screw, with which extension is made on the limb. This same principle is carried out in a splint devised by Dr. Shaffer, while a splint devised by Dr. Ridlon, of New York (see Fig. 2693), makes the traction by pulling rather than by pushing. A very common fixation splint is shown in Fig. 2694. This may be made of leather, or hatters' felt, or plaster-of-Paris. It fits accurately, secures good position, or, rather, maintains a good position after it has been secured, and serves a very useful purpose.

FIG. 2694.—Fixation Knee-splint.

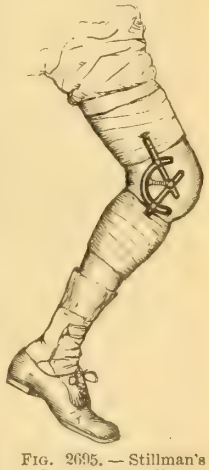


FIG. 2695.—Stillman's Sector Knee-splint.

The sector splint, devised by Dr. Stillman, is shown in Fig. 2695. It is made on the same principle as most of the apparatus devised by this author. We have other splints devised by A. S. Roberts, of Philadelphia, and M. J. Roberts and C. F. Taylor, of New York, all of whom have contributed materially to the history of knee-splints. The splint devised by Thomas,

of Liverpool, is shown in Fig. 2696. It is practically a perineal crutch, and does not require the use of adhesive plaster or plaster-of-Paris. It differs materially, therefore, from the ordinary splints, which depend for their traction and counter-traction upon the use of adhesive plaster. The claims for originality in nearly all these splints are vigorously maintained. Indeed, this joint is so susceptible of control that the opportunity for devising apparatus is very great. In the American splints extension and counter-extension are made in such a way as to obtain either fixation or motion.

Fig. 2696. Thomas's Knee-splint.

One of the latest forms of fixation splint is that devised by Dr. Judson, which consists simply of thigh- and calf-bands, connected posteriorly by a bar of steel or iron which takes the shape of the deformity. This can be altered by wrenches as improvement progresses.

The history of excision of the knee is as follows: Mr. Filkin, of Norwich, England, was the first to perform complete excision of this joint for disease, August 23, 1762. His patient recovered in three months, with a useful limb. The second operation was performed, July 2, 1781, by Mr. Henry Park, of Liverpool. The latter surgeon, however, although he operated nineteen years subsequent to Filkin, was the first to present to the profession the results of his work. The publication of Mr. Park's case brought out the fact that Filkin had done the operation previously. P. F. Moreau, of Bar, France, operated for caries of the knee in 1792. The next operator was Mulder, in Holland (October 21, 1809). Then followed Textor, of Wurzburg, in 1821; Crampton, of Dublin, in 1823; Syme, of Edinburgh, in 1829; Demme, of Berne, Switzerland, in 1835; Lamberto, of Italy, in 1842; and Wadderman, of New Orleans, in 1852. This was the first operation performed in America, although Quackenboss and Kinloch, who performed the operation in 1853 and 1856, respectively, have been regarded by some as the pioneers in this field.

The modes of operating are varying from year to year, and a detailed account of these is probably unnecessary. Since the advent of Listerism the results are much more brilliant, and the technique of the operation is vastly improved.

The Ankle-joint.—Apparatus for the treatment of disease of this joint consist principally of means for fixation, more or less perfect. Many, it is true, have devised splints the aim of which is to produce traction, but when we remember how intimately associated the bones of the ankle-joints are, we realize how difficult it is to effect much in the way of traction; so that the various forms of plastic apparatus, such as plaster-of-Paris, leather, hard rubber, and felt, serve the purpose of fixing this joint. As an illustration of the ankle-splint used for traction, see Fig. 2697, known as the Sayre splint of the shops.

Fig. 2697. Sayre's Ankle-splint.

The history of the excision of the ankle-joint begins with 1670, when Fabricius Haldanus excised the entire astragalus; this was for luxation, and not disease. Gouey, of France, in 1716 removed a portion of the fibula at one operation, and at a second one a portion of the astragalus for necrosis. The next operation for disease seems to have been in 1788, by G. F. Moreau, of France; at this time he removed the astragalus and the scaphoid. Mulder, of Prussia, was the first to operate in that country, which was in 1810. Liston did the operation first in Scotland. Thomas Welles, of Columbia, S. C., operated first for disease in this country.

Fingers and Toes.—One of the most important deformities of the finger that the surgeon has to contend with is that known as Dupuytren's contraction. In 1832 Baron Dupuytren, a French surgeon, published an account of a contraction of the fingers which had been recognized before his time, yet had never been fully described. His description of a hand showed the contraction to be in the palmar fascia alone, but M. G. Goyrand in 1835 published a paper in which he proved that the palmar fascia was not the only tissue involved. These descriptions were important, because of the first encouragement offered for treatment. The method advised by Dupuytren was by open wound, and apparatus was employed to supplement the treatment. The surgeons who figured most extensively in operating were Mr. Adams, of London; Cæsar Hawkins, of St. George's Hospital, London; Busch, of Bonn; the late Alfred C. Post, of New York; and the late Sir William Ferguson. Many of these operators employed the subcutaneous method. It remained for Mr. Adams, however, to devise the simplest form of treatment, and to this ingenious surgeon we are indebted for the most valuable contributions in the literature of this subject. His plan is to make multiple subcutaneous divisions of the fascia and of its digital prolongations. He introduces a small fascia-knife (Fig. 2698), nicking the contracted cords from above downward, while he makes traction at the same time with the finger.

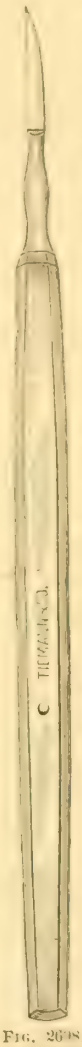


Fig. 2698. – Adams's Fascia-knife.

The splints he employs are simple forms of apparatus, and are applied chiefly to the palm. Dr. Robert Abbe, of this city, a few years since, claimed that this disease was of neurotic origin, and his paper has been regarded as a valuable contribution to the literature of the subject.

In 1864 Professor Annandale, of Edinburgh, presented an important work, the Jacksonian prize essay for the year 1864, on the "Malformations of the Fingers and Toes and their Surgical Treatment." Most of the contributions to this subject since that date depend largely upon Mr. Annandale's work for illustration, and the advances have been comparatively few.

To Mr. Adams we are also indebted for a subcutaneous operation, by means of which cicatrices are obliterated. His operation was first brought to the notice of the profession at the annual meeting of the British Medical Association in 1875, and was published in the *British Medical Journal*, April 15, 1876.

Talipes.—The article of Drs. Ketch and Roberts (vol. ii., p. 196) deals so fully with this subject, and gives in such gratifying detail the history of the operations, the etiology, the pathology, and the therapeutics, that the writer deems it unnecessary to submit the history he has prepared.

The history of osteotomy for correction of rachitic deformities has not been presented in this connection because of the great length to which this article has already grown, and for the further reason that it is dealt with in another part of this volume (see Osteotomy). The same may be said of congenital dislocations, especially of the hip.

In presenting the history of orthopedic surgery the aim has not been to include all the publications on this subject, or all the appliances devised for the treatment of deformity. But it has been simply to present, in as succinct a form as possible, the important progress made up to the present time. Much has yet to be done in this specialty, especially in this country, where the greatest advances in therapeutics have been made. Italy to-day has

a very creditable journal devoted to this special subject, yet no such progress has been made in that country as in the United States. *V. P. Gibney.*

OSMIC ACID. In medical parlance the title *osmic acid* is given to the body *osmic tetroxide*, OsO_4. True osmic acid (H_2OsO_4) is not known in the free state. Osmic tetroxide is a volatile crystalline substance, softening at a moderate heat like wax, and melting at a lower temperature than does that body. It dissolves slowly but completely in water, forming a colorless solution, which, however, on exposure to light, rapidly darkens, even to blackness, by decomposition of the tetroxide with formation of the tetrahydroxide, $Os(OH)_4$. Osmic tetroxide is a powerful oxidizer, and, to living tissues, is excessively irritant. Its odor is powerful and disagreeable, and its vapor intolerably pungent and poisonous, with a peculiar faculty for exciting irritation of the conjunctiva. In the event of the inhalation of fumes of osmic tetroxide, hydrogen sulphide ("sulphuretted hydrogen") has been recommended as a chemical antidote, to be also taken by inhalation; but since in this case the remedy is itself a powerful poison, the greatest care would be required in its employment.

Osmic tetroxide is of peculiar service to the histologist, by reason of a faculty it possesses of staining nerve-tissue. As a medicine it has been used recently, by hypodermatic injection, for the relief of peripheral neuralgias. The results have been quite variable, but a certain amount of efficacy for the remedy seems to have been demonstrated. A one per cent. aqueous solution of the tetroxide is used, and the same should be made only in small quantities when wanted, and kept in the dark. Of such a solution, quantities from 0.20 Gm. to 1.00 Gm. (from three to fifteen minims) have been injected at a dose. The injections are made as near as possible to the painful spot. The operation is often severely painful, is occasionally followed by temporary swelling and thickening of the tissues at the site of the puncture, and, practised over an efferent nerve, has in one instance been followed also by paralysis. No constitutional effects have followed these injections. *Edward Curtis.*

OSTEITIS, OSTEOMYELITIS, PERIOSTEITIS. Inflammation of bone may be induced by simple traumatism—as a fracture or stripping away the periosteum—by thrombosis or embolism of a nutrient artery, by extension from a periosteitis, by extension from arthritis, by exposure to cold, or to the action of certain poisons, as phosphorus and mercury, by syphilis, by pressure—as the rarefying osteitis of aneurism—by the eruptive fevers, especially typhoid, possibly acting as a primary, and certainly as a predisposing, cause. Lastly, but most important in etiological classification, by certain germs either introduced through compound injuries, or else carried to the bones in the circulation. The emphasis which should be laid upon this last factor in the causation of osteitis cannot be over-estimated.

It is of little clinical value to classify the inflammations of bone, from an anatomical stand-point, into osteitis, osteomyelitis, and periosteitis, since primary periosteitis, with the exception of the traumatic and the syphilitic varieties, is very rarely observed; and, on the other hand, every case of myelitis leads, sooner or later, either rapidly or slowly, to involvement of the periosteum in the inflammatory process.

Regarding the firm bony substance itself, when compared with the marrow and periosteum, it may be truly said not to take any active part in inflammation; and therefore osteitis, in a narrower sense of the word, as compared with myelitis and periosteitis, is unimportant. The firm bone is passively affected, however, as we shall subsequently notice; and clinically the death of the bone, or a part of it, is of course of the greatest gravity. So much is this true that it has been customary to study acute osteitis under the title of a frequent result of it—necrosis—and a certain chronic osteitis under the heading of caries.

Periosteitis, like osteomyelitis, may originate from traumatism either simple or compound, and in character may be simple (that is, aseptic), or septic, from the presence of micro-organisms, of which we shall treat later. Syphilis should probably be classed under this latter heading, although we cannot to-day speak with certainty as to its germ origin. The periosteum is first affected during the secondary stage of syphilis, that is, the stage of invasion following the incubation of the syphilitic virus in the system. Those bones which are subcutaneous seem especially liable to periosteitis—the tibia, sternum, ulna, for example—but the others are not exempt. In severe cases there sometimes appears to be a simultaneous involvement of most of the bony sheaths of the body, with consequent almost unbearable osteocopic pains. These pains are distinctly worse at night, and seem increased by warmth; but I am inclined to think that sufferers from osteitis and periosteitis of other than syphilitic origin also complain most at night.

The syphilitic periosteum is quite tender, and I have many times noticed pitting on pressure. In this disease it is rare for the periosteum to become separated from the bone by exudations; and consequently necrosis, from failure of the superficial blood-supply, is very infrequent.

In the later, or "tertiary" stages of syphilis, nodes, usually flat, and of sharply defined extent, sometimes make their appearance. They are caused by infiltration of the periosteum with small round cells, and, like all gummata, tend to soften and break down. Their course, and the probability of bone involvement, seem influenced for the worse if the medical attendant, finding fluctuation, use the knife instead of rapidly pushing the iodides, or other appropriate medicines.

In acute periosteitis, when accompanied by free exudation of fibrine, serum, and pus, the cortical lamellæ of the Haversian systems may be separated from their vascular supply; and unless the surgeon promptly realizes the state of affairs, and makes free incisions down through the dense, unyielding periosteum to the bone, a necrosis of more or less superficial character may, and often does, result.

The clinical picture of acute periosteitis is best studied, as it will be later, together with osteomyelitis; since both are so commonly associated.

A rather rare concomitant of an acute osteomyelitis, usually of a mild type, is a periosteitis with exudation of a simple serous character between sheath and bone. Because of the abundance of albumen in this fluid, Ollier here adopted the title of "osteitis albuminosa."

Chronic, non-infective periosteitis may be either fibrous or ossifying. In the former there is much increase in the amount of connective tissue, and the thickened membrane adheres unusually closely to the bone. In the latter we have as a result an ossific deposit, which may continue during months and years and result in exostoses or osteophytes. I have discussed these formations under the head of Exostoses, in vol. ii. of this work. The new bone of inflammatory origin is not deposited in regular systems of lamellæ, probably owing to faulty nutrition, and it is sometimes absorbed, and disappears—the abnormal activity of the osteoblasts ceasing. This variety—ossifying periosteitis—may be associated with either rarefying or condensing osteitis.

Regarding tubercular periosteitis, it is especially apt to appear in the subjects of the so-called scrofulous diathesis, and in the poorly nourished, and to be accompanied by tubercular osteitis. The discussion of its symptoms, course, and treatment need not be disassociated from that of the latter disease.

Osteomyelitis.—The terms osteitis and osteomyelitis will be considered as one. Where the vascular changes greatly predominate, where pus, fibrine, and serum are abundantly produced, where the brunt of the inflammation is felt by the marrow and contents of the Haversian spaces, the latter term may be applied with especial propriety. And those cases in which changes in the firm bony structure itself form the prominent feature may properly be designated as osteitis. However, the two go hand in hand. Changes in the relative density of the

bony structure can occur only through cellular activity in the marrow-spaces and vascular canals.

These changes are of two kinds—osteoporosis, or rarefying osteitis, and osteosclerosis, or condensing osteitis.

In the former the character of the bone changes from compact to cancellous, and if the process continue the bone may even entirely disappear, its place being taken by a granulation-mass. This variety of osteitis is very common. It is an essential element of tubercular osteitis; it is the process by which the rough, ossified callus following fractures is rounded off; and when a bone is subjected to pressure—as by a growing aneurism—it is a rarefying osteitis by which it is eroded.

In the latter (osteosclerosis) the bone grows more compact, and may even—as seen in some exostoses—become as dense as ivory.

It often happens that both osteoporosis and osteosclerosis are going on at one and the same time in different parts of the bone: an osteoporosis within, for example, and an ossifying, even condensing, periostitis externally; and as a result the bone may become widely expanded, although it is a mere shell filled with granulations or with inflammatory deposits.

Or, again, following an osteoporosis, may occur the opposite condition, and the cavities caused by the former morbid process may become filled with new bony deposit, perhaps of even abnormal density.

We do not yet know why inflammation of bone results sometimes in one and sometimes in the other of these conditions. Neither is their exact cellular cause well understood. It is supposable that in condensing osteitis the osteoblasts have an undue activity. In rarefying osteitis the absorption of bone is thought by some pathologists to be caused by the presence of certain large, multinucleated cells—the myeloplaxes of Robin—called, from this idea, osteoclasts. In subacute osteomyelitis ragged holes, opening from the marrow-spaces and Haversian canals, are worn in the solid bone. These cavities are known as the caverns or lacunæ of Howship. They contain many of the so-called osteoclasts, which, if not the cause, are certainly the witnesses of the osteoporosis.

Other pathologists disbelieve that these large cells possess any such power, and attribute the absorption to the influence of the new granulation-tissue present in these cases, and lying in contact with the bone. They think, as Billroth holds, that just as a granulating synovial fringe erodes the articular cartilage against which it rests, "like ivy climbing over a ruin," so here in bone the granulations possess a similar disintegrating power.

In acute osteomyelitis the vascular changes are of the deepest import, since obstruction of the nutrient arteries means death *en masse* of the bone. Let us study the common cases of apparently spontaneous origin. Here the marrow-tissue is at first of a deeper red, from intense congestion. Sometimes it is mottled with hæmorrhagic spots. Later a grayish hue appears, due to the presence of great numbers of pus-cells; and occasionally little medullary abscesses develop. In bad cases not only does thrombosis of the nutrient vessels occur, but gangrene of the marrow and of the contents of the Haversian canals takes place, with rapid liquefaction. The bone-cells are no longer nourished, and die. The infection may spread rapidly, involving the whole length of the bone, or, in the milder cases, may remain limited to a comparatively small area.

Usually the process begins in the bone, and extends thence along the course of the nutrient vessels to the periosteum, which then becomes involved. Some surgeons think that the poison spreads also through the canaliculi, from bone-cell to bone-cell, and from centre to surface.

Sometimes the reverse is the case, the periosteum being first attacked. Inflammatory products—pus, fibrine, and serum—rapidly strip the swollen and œdematous periosteum from the bone, inducing the most frequent form of necrosis—that of the superficial lamellæ.

The pressure caused by the exudations is very great; so much so that fat contained in the medullary tissues may be forced out, and can sometimes be seen in globules upon the surface of the pus (Röser).

The pus finally breaks through the periosteum at some point of softening and disintegration; it enters the intermuscular connective tissue, and may finally reach the surface. In that case the pus can sometimes be seen to pulsate from its contact with the richly vascular medullary substance.

When the osteomyelitis is near a joint, the articular lamella may become involved by extension, perforation through the cartilage may occur at some point, and the most dreadful arthritis ensue. In the young, separation of the epiphysis from the shaft may, after a week or two, occur. The cartilaginous epiphysis, from its comparative lack of vascularity, is not so subject to attack as the adjacent bone; yet even this may die.

Those parts of the bone which are cut off from their blood-supply die in consequence; and this necrosed bone, upon its subsequent separation, is called a *sequestrum*. Next in frequency to the cortical sequestrum is the central—that about the main medullary canal. In extreme cases the whole thickness of the bone, or even the whole bone, may die. This separation of living from dead bone occurs only at a much later period, however—an average of perhaps three months.

Along the line of demarcation between living and dead bone, granulations spring up, starting from the blood-vessels. The granulation-tissue seems to possess the power to erode and absorb the dead bone with which it is in contact, until at last the sequestrum lies loose upon a bed of granulations springing from the sound bone. In the process of solution of the dead osseous substance, whereby separation is effected, certain salts not soluble in an alkaline medium—such as calcium phosphate—are dissolved and disappear. Hence it is thought that the granulations evolve an acid. Formerly it was believed that lactic acid was the solvent. Tillmann's later researches seem to show that it is the carbonic acid contained in the blood which dissolves the dead bone-tissue.

Unfortunately, the process of absorption is extremely slow, so that we can hardly hope for the complete disappearance of even a moderate-sized sequestrum. Signs of absorption, however, are found upon almost all loose dead bone.

When a sequestrum is superficial, nature is sometimes able to extrude it, and new bone, the *involucrum*, is formed from the granulation-tissue, and pushes the sequestrum out. More commonly, however, it cannot escape. The greatest growth of involucrum springs from the periosteum, save in those cases in which the bone-forming layer of the periosteum has been destroyed by the suppurative process; and this new bone of periosteal origin, while it strengthens the shaft as a whole, prevents the escape of the sequestrum. The reason for the failure of a central sequestrum to be ejected is obvious.

For mechanical reasons, therefore, nature cannot, as a rule, complete a cure after separation of the sequestrum. The case will continue indefinitely, pus being discharged through more or less tortuous openings, called *sinus*, unless the surgeon interfere. He must chisel, saw, or drill through the ensheathing involucrum (involving the transverse diameters as little as may be) and release the imprisoned dead bone. It is very unwise to delay interference after the bone is found to be loose in its cavity, since the patient is thereby subjected to serious danger from exhausting suppuration, from amyloid degeneration of the viscera, from involvement of the neighboring joints in the inflammation, and from hæmorrhage, through mechanical erosion of some large nutrient vessel by the jagged sequestrum.

Although we have discussed to some extent the pathology of acute suppurative osteomyelitis, we have not as yet dealt with its true cause. The question arises, Have we not here to deal with microbes? Numerous accurate investigations of the pus obtained either directly from the medullary canal or from the depth of the tissues surrounding the bone, and subsequent pure cultivations, have settled this question definitely. Lücke and Recklinghausen have thus shown that numerous cocci and bacilli are invariably present. The most important of these seem to be the golden and the white *staphylococcus*,

the *S. pyogenes aureus* and *S. pyogenes albus*. Kocher further demonstrated that aseptic irritation of bone-marrow will not induce suppurative osteomyelitis; but the introduction of a putrid fluid will sometimes do so. It is now known that the germs of putrefaction are not necessary to the suppurative process, but that other germs are.

At a still more recent period Rosenbach, in studying the subject, came to the conclusion that the *S. pyogenes aureus* is in all probability the especially active agent in acute infective osteomyelitis. It has been found that if a pure culture of the staphylococci be injected into the blood of an animal which has first been subjected to fracture or contusion of a long bone, the animal dies in about two days; and on autopsy abscesses are found in the bones and around them, at the seat of injury, and also sometimes in the lungs and kidneys.

How are we to explain the entrance of these germs without an apparent traumatism as a doorway? The only plausible assumption seems to be that they pass in through slight abrasions of the mucous surfaces of the body. Clinical facts support the theory that, preceding myelitis, patients will be found to have suffered from bronchitis, enteritis, etc. (Kocher).

The majority of cases of this disease, with the exception of suppurative myelitis in connection with compound fracture, occur during the time of the development of the skeleton—during childhood and adolescence. One is inclined to think that the physiological growth of the bone predisposes to inflammatory processes. This theory finds support in the fact that in most cases of acute and chronic myelitis the disease is found to be near the epiphyseal cartilage, and therefore in the most newly formed bone. It furthermore seems to appear with greatest frequency in that end of a long bone which furnishes the greatest amount of growth, and in which the current of blood is least active. It is commonest in the upper end of the tibia, and the lower end of the femur; in the upper end of the humerus, and the lower end of the radius and ulna. It will be remembered that the nutrient arteries of the long bones of the lower extremity run *away* from the knee; and in the upper extremity they run *toward* the elbow.

The selection of the youngest bone-tissue as the favorite nidus of the microbes seems dependent upon the peculiar form of the developing blood-vessels. It will be found upon investigation that the sprouting blood-vessels of the growing long bone correspond to wide, hollow spaces close to the epiphyseal cartilage. It will be easily seen that the blood-current grows less rapid in these lacunæ, where the capillaries enlarge, thus giving the cocci contained in the blood a better opportunity to adhere and remain. It is further stated (Hoyer, Rindfleisch) that the blood of the medullary canals flows unenclosed by any tunic in these spaces, and thereby the cocci are brought into direct contact with the bone.

Schiller has demonstrated by a series of experiments that coloring matter introduced into the circulation is retarded in its course and deposited in the blood-vessels of the youngest bone-tissue; thus showing, as Hueter says, an inclination to leave here as a sediment the cocci contained in the blood. This being so, we can readily understand how the infection of the young medullary substance occurs.

Clinical Picture.—Sometimes exposure to cold, a wrench or a blow, exhaustion from eruptive fevers, etc., may act as predisposing causes, determining either the time or the seat of the attack, or both. Or again, no cause whatever may be discoverable. In any case of acute, suppurative osteomyelitis the actual and exciting cause is probably always bacterial.

The disease usually begins with one or more chills, followed by fever, which is often very high. In a child delirium is common, and the little sufferer may not be able to point out the seat of pain, which, however, rapidly becomes severe.

With the intensity and mode of infection, and the degree of vital resistance possessed by the patient, the symptoms vary. He may even die within a day or two, overwhelmed by the poison. To rather less severe cases, from a resemblance in the violence of their onset and symptoms, Chassaignac has given the title "typhus des membres." Later, and in more insidious cases, typhoid fever may be simulated. There may be some slight resemblance to a cellular erysipelas. Judging from constitutional manifestations alone, a dozen other absurd diagnoses have been made.

Repeated rigors and pyæmic temperatures may point to the involvement of more than one bone, or to suppurating foci elsewhere. The disease with which that under consideration is most often confounded is acute articular rheumatism, especially when more than one long bone is attacked. The local symptoms, however, will soon clear up the diagnosis unless, owing to delirium of the patient, the doctor neglects an examination of the limbs. Rather near the articular end of the bone, as a rule, a deep swelling is soon observed, and this is exquisitely tender and painful, the tenderness ending suddenly at the limits of the swelling. This is caused first by the great congestion and œdema of the periosteum and adjacent tissues, and later by the stripping of the periosteum from the bone by inflammatory products.

The skin over the swelling is not reddened at this time; it may even be paler than normal. Later, when the pus is about to escape through some disintegrating point of its dense sheath, the skin becomes reddened, softened, and gives way.

After a week or more, diastasis is liable to occur. To avoid this misfortune, maintenance of the limb in a straight position on a splint may be of some avail.

If the disease continue, the death of some portion of the bone may take place, with the pathological sequences already sketched; or, in mild cases, it is possible that no necrosis whatever may supervene; and—very exceptionally—cases are seen in which there may be resolution without suppuration.

Regarding the *treatment*, during the early stages it should be incisive. There is suppuration either present or threatened, and that, too, beneath dense, unyielding tissues. The indication is plain, and must be carried out without delay. A free cut should be made, through the periosteum, clear to the bone; and with a dressing-forceps entered closed and withdrawn opened, the wound should be enlarged for free drainage. The wound should be irrigated with some antiseptic solution—bichloride of mercury 1–2,000, for example—and, if the incision has been made through deep tissues, a drainage-tube is to be inserted to the bone. Otherwise the wound may be packed loosely with wet antiseptic absorbent gauze.

When, in 1854, Chassaignac and other French surgeons advocated a similar free incision, their advice was followed by disastrous results; generally pyæmia and death. That was before the days of antisepsis. To-day, any surgeon who knows what surgical cleanliness means can make such an incision without threatening the life of his patient; and it is, in fact, his duty to do so.

Whether this incision alone will be of much value will depend upon whether the infective nidus was situated in the periosteum, or whether that membrane was only secondarily involved by extension of inflammation from the marrow. The latter supposition is in most cases the correct one, and may be considered almost a certainty if drops of free oil be observed between periosteum and bone—evidently having been forced out by the tremendous pressure within the bone.

It is well to wait a few hours after cutting to the bone. If, at the end of this period the local and general symptoms seem aggravated rather than diminished in intensity, showing that the trouble is within the bone, and not mainly periosteal, then the trephine should be used, or the burr or chisel, and the marrow should be exposed, irrigated, and freely drained. This may be done at several places if the disease seem extensive.

Such treatment seems radical, but is really conservative of the patient's limb, and possibly his life.

The internal treatment is supportive. It is, perhaps, of little avail to give antiseptics; still, the safer ones—as benzoate or salicylate of soda—may be employed.

Many points which I have left untouched, including

the surgical treatment of the later stages of osteomyelitis—when necrosis is present—will be found in this volume under the heading Necrosis. It may be allowable, however, for me to call attention to two methods of after-treatment which mark an advance in surgery. The first is that of Neuber. After removal of the sequestrum, to obviate the necessity of a tedious healing by granulation, this surgeon has suggested stripping up the integument and subjacent connective tissue for a short distance on either side of the wound, and stretching these flaps into the bottom of the bone cavity so that they meet, or nearly meet, each other. They may here be retained in place by nailing them to the bone. The resulting deep dimple in the skin is not permanent. Connective tissue, newly formed between bone and skin, soon allows the latter to rise; and finally bone takes the place, more or less completely, of this connective tissue.

The other, and more recent method, is that for which Schede deserves the credit. It consists in allowing the wound, after removal of the sequestrum, to fill entirely with blood-clot. This, under perfect asepsis, does not break down or putrefy, but undergoes rapid organization, blood-vessels springing into and permeating it from all sides. This idea, so far as it has yet been tried, seems an excellent one. It is, of course, unsafe unless accompanied by absolute cleanliness and protection from atmospheric germs.

There are certain subacute and chronic cases of osteomyelitis, limited in extent and indicating a mild degree of bone-infection, which deserve mention. They are accompanied by more or less pain and tenderness of the bone over a small area, and this may continue for months and years with slight or no constitutional symptoms. In some of these cases, called "Brodie's abscess," the pus may finally reach the surface, or may remain permanently surrounded by compact bone. An osteoporosis has occurred, sufficiently great to hollow out a pus-cavity, usually lined with granulations; but commonly no necrosis—no death *en masse*—takes place. It may be that a few of these abscesses represent the site of softened and broken-down gummata of late syphilis.

The treatment is self-evident. By means of the trephine the cavity is to be reached and drained. Even supposing the diagnosis to be erroneous; supposing the case to be in reality that uncommon disease, a neuralgic osteitis—one in which a chronically congested vascular state in the bone seems to induce nerve-dystrophia and consequent neuralgia—experience proves that penetration of the bone gives the surest relief, and is a safe operation.

Rheumatic Osteitis does occur, but is very infrequent, and is apt to be secondary to rheumatic periosteitis. The co-existence of rheumatism elsewhere in the fibrous framework aids the diagnosis. Heat, counter-irritation, and, as a last resource, opening the bone, give the greatest relief, and should be conjoined with the usual purely medicinal and hygienic means of treatment.

Tubercular Osteitis.—Under this title we shall briefly discuss that inflammation of bone which, until within a few years, writers have studied under the name of caries; paying more attention, as in necrosis, to the result of the process than to the causative agent.

This is a chronic malady, affecting mainly the red-marrowed, cancellous bones, such as the bodies of the vertebræ and the carpal and tarsal bones. It is essentially an osteoporosis, with tuberculous deposit as its cause and accompaniment, and results in molecular death of the bone. Sometimes, by extension, the compact tissues are involved, but here the bone first changes its character, becoming cancellous through osteoporosis; and later even the remaining bony trabeculæ may disintegrate, and a suppurating cavity be left. The lime-salts are dissolved, and the remaining membranous or gelatinous bone breaks down under the devitalizing tubercular influence.

It may be objected to the term *tubercular* that caries is not always of this nature. It is undoubtedly true, however, that chronic, granulating, rarefying osteitis is commonly so, and at the present day the cases of caries in which careful investigation fails to find the bacillus tuberculosis are very few, and becoming fewer.

The bone frequently expands in one or more of its diameters while becoming a mere shell filled with pus, bony detritus, and granulations. Apparently the growing granulation mass forces out the walls, when they become thin enough to permit it. A rather common example of this condition is found in "spina ventosa." Here the bone—a metacarpal, for instance—may become of a spindle shape. Syphilitic dactylitis may produce the same distention; this latter inflammation is usually a result of inherited syphilis.

This tubercular deposit may be to the eye distinctly tubercular or it may not. It may undergo caseation, or may, as it usually does, soften and liquefy. Some suppuration is probably always present, but this varies greatly in degree. In the caries of children it is almost always a feature. Pott's disease, for example, is accompanied by the formation of so-called "cold abscesses" of varying size, and the pus starting from the disintegrating bone follows a downward course, governed by gravity and the path of least resistance, and may finally open upon the surface. Or, in cases with less discharge, the pus may become cheesy, its ensheathing connective-tissue covering undergo calcareous deposit, and the abscess may never advance far from the diseased vertebral bodies which gave it origin. Such an abscess may be discovered only at the autopsy.

In the elderly subject, granulation mainly, and slow advancement of the disease, are to be expected, with but slight discharge—a "caries sicca."

Tubercular osteitis may occur at any age, but early childhood is especially subject to it. Its onset is usually insidious. The patient may, after a time, complain of a little tenderness or aching after exertion. Later, some swelling of the bone may perhaps be noted. The skin is not involved at first. After several weeks—possibly months—it is distended, reddens, breaks down at one or several points, and pus is discharged. This pus varies in consistency, and is sometimes gritty to the feel, containing minute spiculæ of bone. A probe introduced may—if the sinus be moderately straight—touch bare bone, and may by moderate pressure be made to fix itself firmly in the cancellous tissue; this could not be done with the compact sequestrum of necrosis. The lips of the sinuses and their walls soon become lined with flabby, inactive granulations, in which the bacilli are sometimes to be discovered. Meanwhile the patient may be subject to more or less fever, night-sweats, and similar signs of vital depression.

By extension a caries may involve an adjacent joint, with resulting "white swelling" and all the manifestations of tubercular osteoarthritis. Or, conversely, a primary joint-tuberculosis may lead to erosion of the articular lamella of the bone, and then to tuberculosis of the cancellous tissue.

Caries commonly, though not invariably, makes its appearance in those of the so-called scrofulous diathesis—those especially subject to affections of the glands, skin, and mucous surfaces. Often a family history of tuberculosis may be obtained, or it may be learned that the parents died from some unnamed lung-trouble. The patient is apt to be pale and anæmic in appearance, though not always. Niemeyer's classification of the scrofulous into the erethitic and the torpid applies fairly well here. In adults the bone disease is sometimes a reappearance of inflammation which existed there for a time during childhood, and remained for years quiescent.

At any stage in its progress the disease may come to an end, and reparative processes of varying degree begin. Caries does not necessarily go on to the complete destruction of all the cancellous bone involved. If the patient's general condition can be improved, so that the vitality of the bone is enabled to resist the tubercular encroachment, suppuration may cease, fistulous sinuses close, and new bone form to some extent. This is the rule in Pott's disease. The bodies of one, two, or sometimes more vertebræ melt away, the comparatively sound bodies above and below come in contact, and if the patient live, as he

commonly does, the disease is brought to an end, and these bodies unite by bony union.

In some bones—the calcaneum for example—there is very little tendency to bony repair. The space once occupied by bone becomes partly filled by connective tissue alone.

There is one point regarding the prognosis, and directly affecting the treatment of caries, which must be borne in mind; that is, the danger of general tuberculosis starting from this local process. Although such a catastrophe is quite exceptional, it does sometimes occur. Therefore, where it is possible to remove by surgical means the diseased bone, it should be done.

It has even been suggested, of late, that in spinal caries an attempt be made to scoop away the diseased tissue and thus hasten recovery; if need be, resecting one or more ribs to allow thorough work. But whether this become a recognized practice or not, in all freely accessible regions the proper treatment consists in the free use of Volkmann's sharp spoon, all that yields readily being removed; and the most thorough work will be the best. As with suppurating tuberculous lymph-nodes, so here, this treatment may save months of effort on the part of nature to remove the tuberculous deposit.

It goes without saying that surgical cleanliness must be used during and after the operation—for it is to be regarded as an operation.

It is to be expected that, in many instances, one such scraping will not suffice entirely to put a stop to the disease. Perhaps the step may have to be repeated a number of times before all the affected tissue is reached and eliminated. If the fistulæ continue, or after closing reappear, injection of strong tincture of iodine, which is an excellent germicide, may serve a good purpose. In obstinate cases, after scraping, the tincture of iodine may be thoroughly swabbed on the bone; or the actual cautery may be employed to sear lightly the apparently sound bone. If a sequestrum follow, it will be but superficial and aseptic.

The prognosis in children, after such thorough treatment, is fairly good. In adults it is rather more difficult to eradicate the disease completely. In the tarsal bones, for example, it is questionable whether in adults it is not wiser to excise entirely the affected bone or bones in order to prevent a relapse.

When in spite of thorough local treatment the disease extends, amputation at some distance may be our only remaining resource.

Regarding medicinal treatment, cod-liver oil, iron, and good nourishment are to be employed to improve the general condition. In the phlegmatic temperament cold bathing daily is of more value than the oil. These means, however, will not remove the bacilli from the bone-marrow. They are merely useful adjuvants to the proper treatment.

There are certain cases of osteitis, which are met with in practice, which may fairly be termed hybrid or mongrel cases. They combine features of acute suppurative osteomyelitis with those of chronic, granulating osteomyelitis; and it is presumable that the micro-organisms of both diseases co-exist, finding a nidus and developing at one and the same time, with resulting necrosis from the one cause, and adjacent molecular death—caries—from the other.

Or again, these diseases may not both be present at the start, but one may, after a time, be superadded. For example, a patient may have suffered from acute osteomyelitis and is carrying a necrosis which is not yet a sequestrum; and meanwhile, through one or more cloacæ there is a purulent discharge. Such a patient, through tubercular contamination of his sores—as by a handkerchief soiled with tubercular sputa—may inoculate the walls of the cloacæ with tuberculosis, and thence the infection spreads to the bone, with resulting caries.

Or the converse may be the case. Tuberculosis of bone being present, some alleged surgeon aids his diagnosis by introducing into the fistula leading to the bone a more or less clean probe, possibly taken direct from his pocket-case. The probe is generally less clean—perhaps was last used in opening an abscess, and wiped off. As a result, in addition to the tubercular inflammation an acute suppurative osteomyelitis is lighted up, with all its attendant dangers.

Osteitis from syphilis and from phosphorus-poisoning will be found discussed under the heading of Necrosis.

Robert H. M. Dawbarn.

OSTEOCLASIS. The rectification of deformities of the long bones by means of fracture, by manual or instrumental force is not a new procedure. In the earliest surgical writings this method was advocated, but it was not until the use of anæsthetics became general that it was brought into more frequent use. Within the past ten or fifteen years osteoclasis has been practised with increasing frequency, so that now certain deformities are almost always corrected by its means.

Osteoclasis may be instrumental or manual. The latter is appropriate only to those cases in which the bones are small, or to cases of deformity after fracture in which the bond of union is not strong. The amount of power necessary to fracture the tibia of a child is often beyond the strength of the majority of surgeons, so that for this purpose a mechanical appliance is generally used.

Osteoclasis by means of an apparatus, by which considerable power can be rapidly brought to bear upon a bone, has for years been advocated, and many instruments have been devised for this purpose. The earlier operations were for the correction of deformity after fracture that had united at an angle, but of late years the operation has been extended to deformities of the limbs due to other causes.

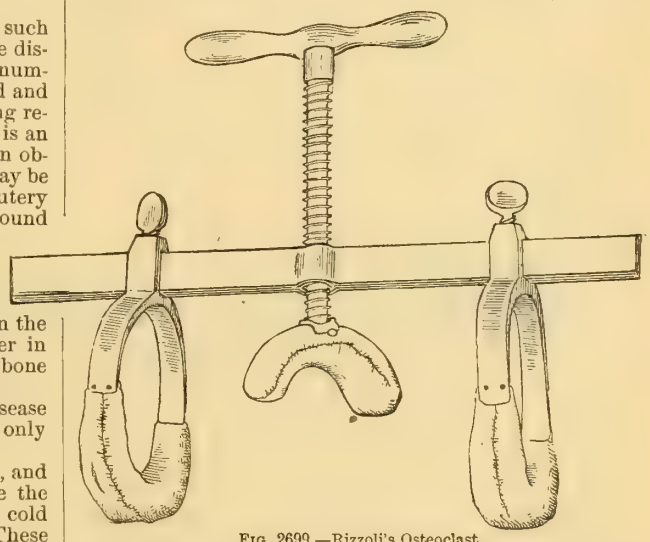


Fig. 2699.—Rizzoli's Osteoclast.

Busch, Louvier, Maisonneuve, and others have constructed instruments for this purpose, some of them being very complicated. In 1846 Rizzoli devised an osteoclast for fracturing the long bones, which, with some slight modification, is still in very general use.

"It consists (Fig. 2699) of a heavy steel bar, 15 inches long, 1 inch wide, and $\frac{1}{4}$ of an inch thick, being much larger at the centre, which is pierced for the female portion of a screw; into this is fitted a round steel bar, half an inch in diameter, on which is cut a thread corresponding to that in the nut on the long bar, and furnished at its upper portion with a handle, and at its lower extremity is a strong, well-padded plate or crutch, forming a segment of a circle. The portion of steel forming the male part of the screw turns in a socket on the upper side of this crutch. Two steel rings, 5 inches in diameter, 1 inch wide, and $\frac{1}{4}$ of an inch thick, having at their upper portion a slot, into which the large bar slides, and by which they are fixed in any desired position by binding-screws, complete the instrument. The lower segments of these

rings are well padded with flannel and covered with chamois" (Poore). "Osteotomy and Osteoclasis").

Dr. C. F. Taylor has devised an osteoclast (*Med. Record*, April 21, 1874, p. 241) for fracturing the femur in a case of bony ankylosis of the hip joint, but the point of fracture is some distance below the trochanter minor, and the resulting deformity is considerable from the angle formed at the point of fracture. An osteotomy just below the trochanter minor gives much better results.

Robin (*Lyon Méd.*, March 24, and April 2, 1882) constructed an osteoclast for producing a fracture just above the lower epiphyses of the femur for the correction of genu valgum. The force was applied in a direction from behind forward. It has been used in this country in a few cases, and has been reported favorably upon, but the writer has had no experience with it.

Collin ("Du genu valgum et de son redressement par l'appareil Collin," Braye, Thèse de Paris, No. 472, 1880) devised an osteoclast for the correction of knock-knee; the force is applied laterally, and the mechanism of the apparatus is very complicated. From some experiments on the cadaver the fracture was found to be irregular and somewhat oblique. In actual practice there was considerable after-pain, extending over several days, and in one case, at least, inflammation of the knee-joint.

Osteoclasis has been employed for the correction of deformities after fracture, for straightening joints ankylosed at a bad angle, and for the rectification of rachitic curvature of the long bones. Osteoclasis for the correction of deformities after fracture of the long bones has been performed by many surgeons. It is an operation attended with but little danger, and has given excellent results. The method of operating does not differ from that for rachitic deformities. Straightening joints that have been ankylosed at a vicious angle is not an operation devoid of danger. After suppurative inflammation of a chronic nature it should *never be attempted*, as there is great liability that the inflammation in the joint will be rekindled and disastrous results have too often followed such procedures. After acute troubles it is not attended with such risks. In these cases manual force is all that can be safely used, and those cases in which the result cannot be accomplished by means of force applied by the hands should not be submitted to an operation with an osteoclast. For certain curvatures of the tibia and fibula fracture by means of this instrument is to be preferred to any other method. It does away with all cutting, takes little time for its performance, and produces a simple fracture under the most favorable conditions. The cases appropriate for osteoclasis are lateral and antero-lateral curvature when the anterior deviation is slight. Sharp curvatures near the knee- or ankle-joint are not suitable, because there is not sufficient space for the application and adjustment of the instrument. Anterior and antero-lateral curvatures, if of marked degree, should always be corrected by cuneiform osteotomy, or the lateral tendency may be treated by an osteoclasis, and later on osteotomy may be performed for the anterior. The reason why the latter should not be corrected by an osteoclast is that the pressure would have to be applied directly over the crest of the tibia, and the soft parts would be injured by the pressure between the crest and the pad of the osteoclast. Besides, in many cases the anterior border of the bone is much longer than its posterior, so that in order to bring the lower fragment forward a wedge of bone must be removed.

The method of using Rizzoli's osteoclast is as follows: "The patient being placed under ether and the desired point of fracture having been determined, the limb is passed through both rings, which are adjusted on the long bar, so that one shall be just above the lower, and the other just below the upper, epiphysis of the tibia. The semicircular pad should be directly over the point of desired fracture on the outer aspect of the limb. It makes no difference whether the steel plate at the end of the screw is equidistant from the two rings; the point of fracture is immediately under it, no matter where it is placed, provided it is far enough from one ring to allow of sufficient space. I do not think that I have ever had less space than two inches. After the instrument is adjusted it is made tight by a few turns of the screw, and then the pressure-pad is driven down rapidly by turning the screw until the bone gives way" (Poore; "Osteotomy and Osteoclasis"). It has been found that with this instrument the fracture always takes place under the pad, and is transverse. After removing the osteoclast the limb is put up at once in plaster-of-Paris, in a slightly over-corrected position. The only accident that has been reported is one case of non-union in a girl of five years, due to sclerosis of the ends of the fragments.

For fracture in bones of an adult larger rings are required.

In the author's experience, which has been quite extensive, no accident has ever happened. The amount of swelling about the point of fracture is not great, and a slough has never been seen. In case an osteoclasis should fail, I would not perform an osteotomy on the limb on the same day, as in one case when I did this there was considerable trouble from extravasation of blood. *Charles Talbot Poore.*

OSTEOMA. The osteoma is a tumor formed of osseous tissue. Strictly speaking, all osseous structures which arise in consequence of inflammation and represent simply circumscribed hypertrophies of bone, and such as develop in indurated tissue, should be excluded from the tumors. Were this done the number of formations included under the head of osseous tumors would be very limited. Bone-formation takes place in a number of tumors, both in those originating in bone and cartilage, and in those which have a different origin; only those in which the formation of bone is typical and represents the end of the pathological process should be considered osteomata. Where the development of bone takes place in other tumors, as in the chondroma, sarcoma, etc., it should be regarded as accidental; and along with the bone the other tissue of the tumor is found. Even in the chondroma the bone is generally of such a character that the cartilage cannot be regarded as representing simply an earlier step in bone-formation. This separation of the osteomata, simple as it appears to be and easy of application to most tumors, is difficult to apply to others. The osteoma, like the physiological bone-tissue, develops from a preceding cartilaginous or fibrous structure. Where the formation of these tissues is typical, and has nothing of a sarcomatous character, doubt may arise, when osseous tissue is present, whether the fibrous tissue or cartilage does not represent an earlier stage of the bone-formation. In the case of many osteomas it seems clear that they at first appeared as chondromas.

The osteophytes should be separated from the osteomata. These are new-formations of bone, often spread over a large surface and closely connected with the periosteum. They are usually the result of an ossifying periostitis, and may be smooth, soft, and spongy, or rough and uneven. They are at first more closely connected with the periosteum than with the bone, but in the course of time their connection with the latter becomes closer and closer until they form a part of it. Various names have been given to these inflammatory formations. When the growth covers a considerable part of the bone it is spoken of as a periostosis. When it surrounds the bone and constitutes a true hypertrophy, it is a hyperostosis. When the process is confined to a limited extent of the bone and the new-formation of bone projects in the form of a tumor, it is called an exostosis; and when it projects into the old bone, as into the medullary canal, an endostosis. They are common in all long-continued inflammations of the periosteum, especially in those of a syphilitic origin. In old cases of ulcus cruris there is often a considerable new-formation of bone at the site of the ulcer. Virchow has proposed the name *leontiasis ossea* for the hyperostoses of the bones of the face and head.

Rokitansky divided the osteomata into two classes, the division depending on the structure of the growth. The first class comprised those which were similar to the

normal bone in their histological structure, and the other included those which differed somewhat from this. This departure from the physiological type consists in the absence or imperfect development of some of the attributes of normal bone, as absence or imperfect formation of Haversian canals, bone-corpuscles, and canaliculi. There is also often an imperfect formation of the lamellæ, and they do not have the typical concentric arrangement around the Haversian canals.

Virchow has divided the osteomata into three varieties, depending on the character of their tissue. All three of these have their prototypes in the physiological osseous tissue. The osteoma durum or eburneum is characterized by its exceedingly hard tissue. It appears especially on the bones of the head and face, and consists of hard, compact bone-substance, often arranged in the form of lamellæ, which run parallel with the periphery of the tumor. The processes of the bone-corpuscles in the lamellæ are turned toward the surface. The tumor contains very few blood-vessels; its surface is rough and covered with a thin layer of periosteum. The physiological type for these tumors is the cement-substance of the teeth. The second variety, osteoma spongiosum, shows, as does the spongy bone-tissue, narrow trabeculæ and wide medullary spaces. The third variety, the osteoma medullosum, contains wide medullary spaces filled with marrow. These spaces may be so large that they constitute the greater part of the tumor. Such tumors have been designated, in connection with new-formation of bone depending on inflammatory processes, as spina ventosa.

In the main points of their histological structure the osteomata agree with the normal bones, although they have neither the regular architecture of the bone trabeculæ, nor the typical arrangement of the vascular and medullary canals and bone-corpuscles. The tissu contained in the medullary canals shows the different varieties of marrow. Both the fatty and the red marrow are found, and the gelatinous marrow which generally accompanies atrophic processes, as osteomalacia, etc., is also met with in the tumors.

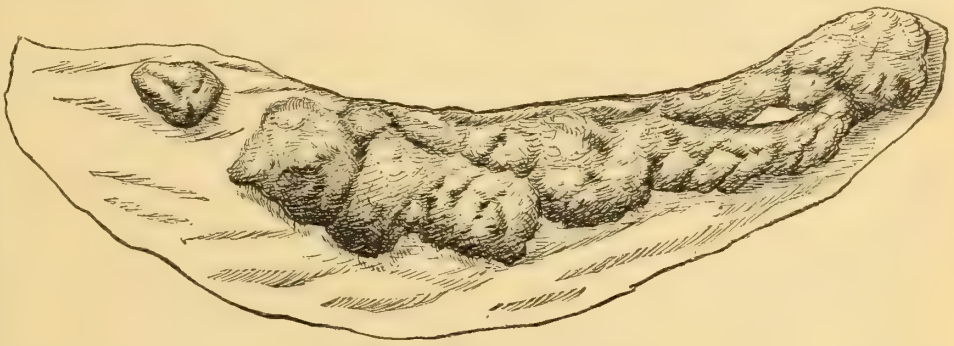


Fig. 2700.—Osteomata in the Falx Cerebri.

Osteomata generally develop from pre-existing osseous tissue, but are frequently found elsewhere. This would divide them into hyperplastic and heteroplastic formations, but they differ from the heteroplastic formations generally in the absence of malignity. The exostoses belong to the hyperplastic formations. They may be divided, according to their mode of origin, into cartilaginous and fibrous exostoses. The former are always covered with a thin layer of cartilage and are found on the long bones, especially the humerus, femur, and tibia. They are most frequently seated at the juncture of the epiphysis with the diaphysis, and probably arise from small remains of the primordial cartilage in consequence of local stimulation. The thorn-like processes which form in the pelvis at the juncture of the original pelvic bones belong to this class. These exostoses, in general, are formed in early life, and cases have been seen where nearly all of the long bones of the skeleton contained them. In an early stage of their development they consist of compact osseous tissue, but in their further growth they become more and more spongy. They sometimes show a tendency to progressive growth, new masses of bone always covered by cartilage being rapidly formed, and in this way tumors of considerable size may be formed. Virchow mentions an osteoma of this sort which grew from the pelvic bones and reached the size of a man's head.

The fibrous exostoses develop from the periosteum and have a much closer relation with this than with the bone. They are closely related to the osteophytes. They are most frequent on the bones of the face and skull, and appear as round or pointed elevations on the inner or outer surface of these bones. Osteomata are occasionally found which substitute their tissue for that of the bone, and project from both surfaces. Rokitansky suggests that they arise from small masses of cartilage enclosed in the bone, an idea which was further elaborated by Arnold in his work on "Osteomata of the Frontal Bone." Virchow thinks that they may arise from the diploë. They are sometimes found in the hollow bones, and Cruveilhier has proposed for them the name of encapsulated bony bodies, *corps osseux enkystés*. Osteomata are sometimes found on the maxillary bones. Both diffuse and circumscribed hyperostoses are found here, but in addition to these, there are tumors which may reach a considerable size. The tumors arising from the teeth form an especial class of the osteomas, the odontomas. They may arise from the normal teeth, from retained teeth, or from the alveolar processes. They often form tumors of considerable size and of most irregular shapes.

Some osteomas are found adjoining the bone, but having no connection with it, which should still be considered with the exostoses. In these the tumor was originally connected with the bone, but in some way the connection has been accidentally broken. In the same way an osteoma may develop on a splinter of bone which has been separated in consequence of fracture. On the other hand, an osteoma may be found closely connected with the bone or periosteum, but which must still be regarded as a heteroplastic formation. Here the tumor has developed in a tendon or fascia at its place of insertion into the bone. Most of these are connected with the bone, but still, cases are seen where they have no connection with it. The analogy for this is found in the sesamoid bones. The formation of these tumors is generally the result of chronic inflammation, and often there seems to be a special tendency to ossification in the subject. They may appear in almost every place of insertion of a tendon in the skeleton.

Osseous growths are sometimes found in the muscles. These are known as exercise bones and rider's bones. They are most often found in soldiers—in the infantry in the deltoid muscle from the constant pressure of the gun, and in the cavalry in the adductors of the thigh. Billroth has seen a case in which a considerable bony mass was formed in the biceps muscle of a young man. In exercising on the horizontal bar he was accustomed to swing, holding the bar in the bent elbow. Hasse found, in an examination of six hundred recruits who had served six months, these exercise bones in eighteen cases. They vary in size from that of a pea to that of a goose's egg. Billroth thinks that where they appear they show a tendency in the individual to osseous formations.

Osteomata are not infrequently found in fibrous tissues, in the form of flat masses, and are generally accompanied by chronic inflammation. One of the most frequent places of their formation is in the dura mater along the falx cerebri. Here they may form either thin,

smooth masses, or rough, uneven, jagged growths. They are most frequently found in the insane, and are accompanied by a thickening of the membrane. They are rarely of sufficient size to give rise to definite symptoms, but in some cases seem to do so. Fig. 2500 shows the falx of a woman, thirty-three years of age, who complained for years of the most persistent headache, which may have been due to this condition. They are also found in the shape of small masses, no thicker than a finger-nail, in the arachnoid membrane of the cord. Meyer has found small osteomata in the skin in the neighborhood of a chronic ulcer. Virchow mentions that they are sometimes found in the skin about the sebaceous glands.

There have been several cases published of the formation of osteomas in the brain, although it is probable that many of the earlier cases were simply calcified cysticerci. The writer has seen two such cases. In the first, a microcephalic brain of an idiot, there were several irregular osseous growths in the cerebral cortex. The largest of these was about the size of a hazel-nut. The second case was an epileptic negro. There was an osseous mass, very irregular in outline and as large as a pigeon's egg, which projected into the right lateral ventricle. Virchow supposes that the bone in these cases develops from the neuroglia, but it may also be regarded as resulting from an ossifying encephalitis.

Osteomas are also found in the choroid of the eye, where they form smooth plates of bone. An analogy is found for their presence here in the eyes of certain birds. Osseous tissue may also be formed in the vitreous, in cases of atrophy of the eye.

In the trachea small, round masses of bone are sometimes found beneath the mucous membrane, and not connected with the cartilage. In the lungs osseous formation takes place in several forms. The indurated connective tissue at the apices often contains bits of bone. In one case which the writer has seen, there was a network of broad, thin masses of bone traversing the pleural surface of almost the entire upper lobe of the right lung. The case was one of old tuberculosis in the apices, with a termination in cicatrization and induration. Bony masses are also often found in the thickened pleura. Cases have been described in which the bone-formation was in the form of round masses, and had no connection with chronic inflammation. It is generally supposed that these growths develop either from the cartilage of the bronchi, or from some remains of the embryonic cartilage. They seem to be more frequent in some of the lower animals than in man. In some rare instances osteomata have been found in the penis, developed in the corpora cavernosa.

There seems to be some relation between the formation of osteomata and chondromata. Both are more frequent in youthful persons, but scarcely ever appear in young children. Both are more frequent in men than in women. The osteomata which appear at the epiphyses cannot be formed after the twenty-fourth year, and few of the other varieties appear after the age of thirty. The formation of these tumors in early life is remarkable, in view of the fact that ossification processes in general take place late in life. The cartilages of the ribs and air-passages do not become ossified until late in life, and the calcareous deposits in the arteries form one of the constant changes of senile marasmus; but still osteomas are very rarely formed in old people, and when they are seen in them their origin is usually to be referred to an earlier period. The growth of the osteoma is always slow, and usually ceases when the bearer has passed middle life. The exostoses of the epiphyses cease to enlarge after the growth of the skeleton is completed and the originally spongy osseous tissue has become compact. As a rule, their presence does not occasion the bearer any discomfort; even the osteomata developed in the muscles seldom reach such a size that the usefulness of the muscle is thereby impaired. They do not occasion any pain while growing, and are not painful to the touch. When they are formed in the neighborhood of an articulation they may reach such a size that the function of the joint is interfered with. Those formed on the facial bones often give the bearer an unpleasant expression. They never do harm, however, except by their local effects. If any tumors deserve the name benign, the osteoma should be so considered.

W. T. Councilman.

OSTEOMALACIA. By the term osteomalacia is designated a disease in which there is a softening of the bones, due to a change in their chemical composition; it is frequently known as *mollities ossium*, occasionally as *malacosteon*; it is to be contradistinguished from *fragilitas ossium*. Billroth has defined the disease as a "fungous, fatty osteomyelitis."

This affection occurs with greater frequency in women, being encountered about ten times in women to once in men. It is most commonly met with in early and middle adult life, but occurs rarely in children. The first manifestations of the disease frequently appear during pregnancy, and anything which causes prolonged depression (especially that of a nervous character) seems to favor its development.

Pathology.—The changes due to this disease, in the long bones, appear first in the medullary canal, then in the medullary spaces and the Haversian system of the cancellous tissue, and finally in the compact bone. The periosteum has little or no part in the disease, and Rindfleisch says that it even checks it, by its nourishing the peripheral compact bone. The disease is progressive; the bones may finally become excavated or riddled with cystic cavities (Pepper's "Surgical Pathology"). In the vertebræ, pelvic bones, sternum, and ribs, the morbid process may begin at several different points in the cancellous tissue at the same time.

At first there is a "very marked passive congestion of the medulla in the central canals of the long bones and in the medullary spaces of the cancellous tissue," capillary rupture may take place, the bony trabeculæ may be absorbed, and the medulla may become liquefied. Hence are formed cystic cavities, which are filled with a sometimes turbid, sometimes clear, albuminous liquid.

The capillaries first become enlarged; they are embedded in a soft gelatinous substance, containing embryonic cells, which are less numerous than in caries; the normal fat-cells have disappeared, and the lime-salts have also vanished; hence there are two zones around the medullary spaces, one of soft, decalcified bone, and the other of healthy tissue (Pepper). The decalcification first occurs in the periphery of the Haversian canals and inner walls of the layers of the marrow-spaces (Delafield and Prudden). The decalcified tissue may be replaced by newly formed marrow or granulation tissue.

Delafield and Prudden say that the cranial bones are rarely much affected; Bryant notes, however, that the large grooves in the cranial bones, due to the increased vascularity, are very striking. Billroth has found scanty deposits of osteophytes beneath the periosteum (Pepper's "Surgical Pathology").

Several different theories have been advanced as to the exact nature of the chemical changes in this disease. Rindfleisch has thought that the free carbonic acid may be the actual cause of the absorption of the calcareous salts. Lactic acid has been found in the urine and bones, but it is more likely a result than the cause of the morbid process.

Symptoms.—Pain is the first symptom; it is deep-seated, and increased by pressure or motion; it may come on insidiously or suddenly, and may be very severe; it may intermit; sometimes it is wandering, sometimes fixed for a time, and then spreading. The pain has generally been first felt in the lower half of the spine and pelvis; in some cases, however, it has begun in the lower extremities. The pain occurring in the early stages of this disease has frequently been mistaken for that of rheumatism. Accompanying the pain is a feeling of lassitude, gradually increasing to actual inability; a feeble gait and fear of falling occur with the early changes (Durham).

Lime-salts are found in excess in the urine; sometimes renal calculi of phosphate of lime are found after death

(Niemeyer). This disease almost always ends fatally, and death generally occurs from exhaustion. It may, however, be several years before a fatal termination is reached. The prognosis is, as a rule, very bad; nevertheless it should be remembered that an arrest or even a cure of the affection is a possibility.

Deformities.—As a result of the changes above described, the bones become more or less curved or suffer more or less complete fracture, frequently causing great deformities. These may be induced by the action of gravity or by muscular contractions. "The ribs may be bent by the pressure of the arm in the axillary line" (Pepper). The spine, from the weight of the body, may be more curved than natural, the vertebræ being more or less rotated. The cervical portion of the column may have an angular curvature, due to the weight of the head. The long bones may present many fractures. "The pelvis assumes a trefoil shape under the action of two forces—the weight of the body, which thrusts the promontory of the sacrum forward and downward, and the counter-pressure through the acetabula" (Pepper). The patient is compelled to remain in the horizontal position. In a case reported by Dr. Lane, in the London *Lancet* for 1884, the ribs, pelvis, and scapulæ presented many points which had the appearance of having sustained fractures, which had healed by membranous union, but which were actually cases of decalcification at those points which sustained the greatest strain.

Although the disease is generally found in adults, as has been stated, several instances of its occurrence in children have been reported.

In a case cited in the *British Medical Journal* (1884, vol. i., p. 213) this disease is reported as occurring in a little girl eight months old. It is stated that Dr. Rehn, of Frankfort, has seen six cases of osteomalacia in children. Sleeplessness and restlessness are said to have been prominent symptoms in these cases.

In a case reported by Dr. Davies-Colby (*British Medical Journal*, 1884) there occurred in a little girl an obscure bone-disease, which was characterized by a peculiar waddling gait. On her being treated for a fracture of the humerus, it was discovered that the long bones were very tender and flexible; it was also noticed that the bones of the cranium could be indented. The patient died at the age of thirteen. It was doubtful whether the disease was rachitis or osteomalacia, but it was probably the latter.

Billroth has mentioned two cases of osteomalacia in the long bones which were associated with caries of the joints, but from the latter fact it is not impossible that the disease may have been "rarefying ostitis and fatty atrophy from disuse" (Pepper's, "Surgical Pathology").

Differential Diagnosis.—The only disease with which osteomalacia is likely to be confounded pathologically in the adult is caries. Osteomalacia attacks several bones simultaneously, while in caries but one bone is affected, as a rule; in osteomalacia "each bone is the seat of scattered foci of absorption and excavation; the lime-salts are absorbed before the organic constituents; the neoplasm softens and liquefies, but does not caseate; in osteomalacia the cavities formed in the bones have regular walls, which are sometimes lined with a fibrous membrane; the disease has but little tendency to subside; it does not begin nor spread beneath the periosteum" (Pepper).

When the disease occurs in children it may be confounded with rachitis; the pain, when persistent in the neighborhood of the joints, may be mistaken for that of rheumatism.

Treatment.—Trousseau advised rest, warmth, good food, and cod-liver oil. He relates cases in which this treatment has brought about good results. According to Durham (Bryant's "Surgery") lime-salts should not be given; they simply throw additional labor on the kidneys, as they cannot be retained. Niemeyer doubts the efficacy of cod-liver oil and iron, as well as of all other forms of medication. He says that the prevention of distortion is all that can be attempted.

It appears, then, that no cure for this disease is known at present, and all that can be hoped for is palliation of the symptoms, and the prevention or relief of the deformities by posture or mechanical devices.

William H. Murray.

OSTEOTOMY. "Osteotomy, in its broadest acceptation, may be defined as a section of bone. It has, however, been regarded in a much more restricted sense, the term being applied to such divisions of bone as have been proposed and undertaken for the relief of deformity, for the rectification of badly united fractures, and for the straightening of limbs affected with osseous ankylosis, which are fixed in a bad position" (Macewen).

Section of the long bones for deformity had been proposed by many early writers on surgery, yet it does not appear to have been put in practice until 1815, when Le Mercier divided the tibia with a saw for a badly united fracture. Barton, in 1826, performed an osteotomy, just below the trochanter major, for ankylosis with flexion of the thigh, through an open wound. Clèmot, Portal, Astley Cooper, Warren of Boston, and others performed similar operations. Prior to 1852 all operations were performed through an open wound. In that year Langenbeck made a division of the femur for ankylosis of the hip-joint by perforating the bone with a drill through a small wound in the soft parts, and then introducing a narrow saw, and dividing the bone. Stromeyer Little, in 1868, used a carpenter's chisel to divide the bone in a case of osseous ankylosis of the knee-joint, making the section through a wound half-an-inch in length. One year later Mr. William Adams performed the operation of subcutaneous section of the thigh-bone. Ogston, May 17, 1876, divided the internal condyle of the femur in a case of genu valgum, and on February 2, 1878, Macewen first performed the operation above the condyles for the same deformity.

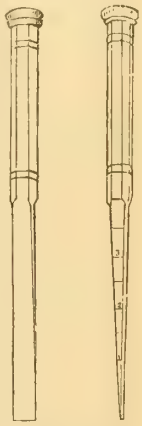


Fig. 2701.—Osteotomes, reduced one-fourth.

Before 1875 all osteotomies were performed through an open wound, and were followed by suppuration more or less profuse, and during this period fatal and unsuccessful cases were not uncommon, while since the above date disasters have been very few. The bone may be divided with an osteotome, a chisel, or a saw.

An osteotome is a cutting instrument of the chisel order, whose plane sides gradually slope down to the cutting edge; it resembles in this respect a knife with an exceedingly wide blade, and which is proportionately thick as it recedes from the cutting edge; the latter is made very sharp, and has the surface of a sharp-edged tool. It should have a temper between that of a carpenter's and a cold chisel, so that the edge will not be turned by the hardness of the bone nor be so brittle as to chip. They should be made of the best quality of steel. Every instrument should be tested on a piece of hard bone, driven in with a pretty strong blow with a mallet; if the edge is neither turned nor nicked, it is of a proper temper. It should be marked in half inches from the cutting surface, so as to afford information as to the distance the instrument has penetrated the bone. It is necessary to have three osteotomes of the same length and width, but of different thickness at about one-fourth of an inch from the cutting edge, in other words, the two planes should form angles of different degrees with each other. Fig. 2701 exhibits the flat and angular aspect of such an instrument; it is reduced to one-fourth of the actual size. The difference in thickness is for the purpose that when one gets wedged it may be replaced by the next smaller, to be again replaced by the smallest if necessary. It is well to have a small instrument one-fourth of an inch wide (Fig. 2702) to divide small bones, such as the fibula. Too much care cannot be taken in the make of this instrument, in regard to

Fig. 2702.—Small Osteotome.

both its size and temper. It should always be remembered that it is a *cutting*, not a prying, instrument, and should under *no circumstances* be used for the latter purpose, as it will almost inevitably be broken if so employed.

The chisel for a cuneiform osteotomy resembles that used by carpenters, except that it is thinner as its two planes approach the cutting edge, and the bevel is much smaller; it should have the same temper and be of the same width as the osteotome.

Osteotomy may be performed with a saw, and with some operators this is a favorite instrument. That known as Adams's is the form generally used, slightly varied in shape to suit the views of the surgeon. It is figured in all recent works on surgery, so that a detailed description does not seem to be called for.

The mallet used should be larger than that found in necrosis cases, a heavy carpenter's mallet is the best. The operator should be provided with a sand-bag covered with rubber cloth, about six inches square. These and a knife are all the instruments actually required for the operation.

Osteotomy may be either linear or cuneiform. The former is performed through a small incision, the latter through an open wound.

Linear Osteotomy.—The patient having been placed under ether and the limb rendered bloodless, if this is possible, the point of section having been determined, the knife is thrust down upon the bone and an incision about three-fourths of an inch long is made, parallel to the long axis of the limb. All the tissues are divided with one sweep of the knife. Unless there are special reasons for so doing, the bone should not be reached by dissection. Of course, if there are any vessels or nerves in the line of incision they should be avoided; this may sometimes demand a different mode of reaching the bone. Holding the knife still in place, the largest osteotome is passed down upon the former as a guide, and when down upon the bone the osteotome is rotated so that its cutting edge shall be at right angles to the long axis of the limb, and at right angles to the line of the incision. It is well to moisten the instrument with some antiseptic solution, and the wound should be kept filled with the same during the operation. After the osteotome is in position, it is driven into the bone by pretty strong blows with the mallet, the limb having been first well embedded in a sand-pillow. After each blow the instrument should be slightly rotated in the direction of its *long* diameter—that is, at right angles to the axis of the bone—in order to prevent its becoming wedged, and also to change the direction, so that the bone may be divided throughout its entire width progressively. In case the first osteotome should become wedged, the next smaller should be substituted for it, and this again replaced by the smallest, if necessary.

After the bone has been divided through four-fifths of its thickness the osteotome is withdrawn, and the section completed by fracturing the bone. A sponge wet with an antiseptic solution is bound over the wound by one or two turns of a bandage, the constricting band removed, and the other limb operated upon if required.

Treatment of the Wound.—After leaving the sponge in place until the circulation in the limb has become fully established, the bandage and sponge are removed. It will generally be found that all hæmorrhage has ceased, but that considerable blood, and perhaps some coagula, can be forced up from the deep portions of the wound. With a sharp pair of curved scissors any piece of fat or cellular tissue that may protrude from the wound should be removed, in order that its edges may be brought into perfect coaptation. Any piece of tissue that may protrude from between the lips of the wound prevents primary union, and is a fruitful source of suppuration. After drying the parts, the edges of the wound are to be brought accurately together with a piece of adhesive plaster, about one-half the length of the wound in width, and extending for some distance on either side of it. The object in not entirely covering the wound is that the part of the cut on either side of the plaster may afford space for the exit of any undue collection of blood which might otherwise separate the edges of the wound and prevent primary union. The parts are then dusted over with iodoform, and a compress of cheese-cloth about three inches square placed over the wound. The limb, if possible, is then enveloped in a flannel bandage, and over this a plaster-of-Paris bandage is applied; before the latter becomes set the limb is placed in the desired position. It is well to overcorrect a little. The object of this method of wound management is to place the parts in such a condition that primary union may take place, and thus convert the fracture into a simple one. On the second day the splint will be usually found stained with blood at the position of the point of operation; this is of no consequence, and need give no anxiety. On the third day it is well to cut a fenestrum over the seat of operation, through which the compress can be withdrawn and the wound examined. As a rule it will be found dry if primary union has taken place, and no further care is needed. If, however, it should be moist, a new compress is to be applied, and the parts must be inspected every day or two until oozing has ceased. The plaster-of-Paris splint may be left on until consolidation has taken place, which, in children, will take about four weeks.

Cuneiform Osteotomy.—The method of removing a wedge of bone differs from that of a simple section in that it is performed through a large wound, and a chisel, not an osteotome, is used. An Esmarch bandage being applied and the point of section having been determined upon, an incision is made down upon the bone, a little longer than the width of the piece of bone to be removed. If the bone is deep seated the cut in the skin will have to be still longer. The periosteum is divided and stripped from the bone upon either side—often it is an advantage to make, in addition, a transverse division of this membrane at a point corresponding with the centre of the first cut, as it will afford additional room and diminish the danger of injury to the soft parts. The size of the wedge to be removed having been determined, the periosteum is held out of the way by blunt hooks placed on either side. The operation is begun by removing a much smaller wedge than is required, by cutting with the flat surface of the chisel toward the part of the bone to be left; the size of the opening can easily be increased by removing alternate slices of bone from either side. Care should be taken that the edge of the chisel is kept inside of the periosteum, for by so doing there can be no danger of injury to the soft parts. When the apex of the V-shaped cut has extended well into the compact bony tissue on the opposite side, the section can be completed either by driving an osteotome directly backward from the apex, or by forcibly bending the limb. If the size of the wedge to be removed has been accurately calculated, the sides of the bone left by the removal of the wedge will come into apposition and the deformity be corrected. After the removal of all small pieces of bone, and washing the wound out with some antiseptic solution, a sponge is bound over the parts and the constricting bandage removed. After the circulation has become re-established the sponge is removed, and any bleeding point secured with a catgut ligature; the divided edges of the periosteum are then stitched together so as to cover the bone. If the wound is deep, the fibrous planes and muscles are to be separately brought together. A counter-opening, to afford good drainage, made from the apex of the wedge down through the muscle, if possible, through which carbolized horse hair is passed, is an advantage, as the hæmorrhage is greater from a cuneiform than from a simple osteotomy. This is especially so when the bone operated upon is superficial. In bones deeply seated there is more room for effusion of blood to take place without causing any tension on the wound. The wound itself should be united with catgut, and then dusted over with iodoform, and a compress large enough to cover both openings applied. The limb is put up in a plaster-of-Paris splint, as after a simple osteotomy. On the next day a fenestrum should be made and the horse hair removed. As a rule, the wound acts just like that from a simple osteotomy. During correction care should be taken that no small

pieces of tissue get pinched between the fragments; if this should happen it will be the starting-point of suppuration.

The success of an osteotomy depends more upon the treatment of the wound than upon the operation itself. It may, however, be laid down as a rule, that the more simple the methods of operating, the smaller the wound in the soft parts, and the less complicated the dressing, the better will be the result. Large incisions and complicated osteotomes are more of a hindrance than an advantage, and the smaller the wound the less conspicuous will be the resulting scar.

Osteotomy of Special Bones.—*For Ankylosis of the Hip-joint.*—In order to have a better understanding of the different operations about the hip-joint for the correction of deformities of this articulation, a short statement of its various causes and the end to be had in view by an operation will be necessary.

Malposition of the femur, with ankylosis, is found after hip-joint disease, fractures near the joint, dislocation, and rheumatism.

Ankylosis after hip-joint disease may be either fibrous or bony; with the former, in some cases, there may be absolutely no motion, and in this respect these cases practically belong to the same class as those of bony ankylosis, as far as the present consideration of the subject is concerned; while in other cases there exists motion to a greater or less extent, but with malposition of the limb. Forcibly breaking up the uniting bands, be they fibrous or bony, is bad surgery; the danger of rekindling inflammation in the bone or surrounding parts is by no means slight, and disastrous results have too frequently followed such operations. Again, even if the bone could be fractured without fear of secondary trouble, the point of fracture is one over which the operator has no control, but depends upon the location of the weakest part of the bone. In osteotomy, on the other hand, the point of division is entirely under the control of the operator, and no injury is done to the surrounding parts.

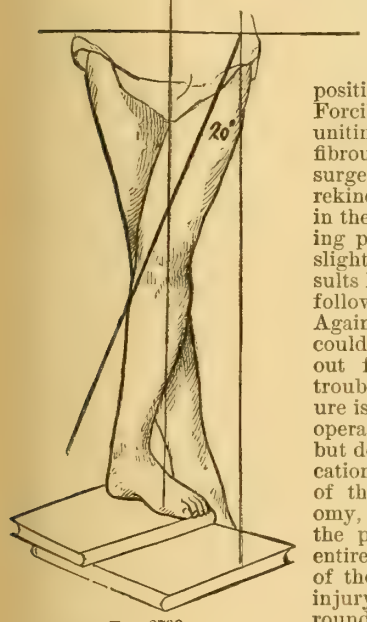


Fig. 2703.

The deformity following hip-joint disease consists of flexion and adduction of the limb upon the pelvis; the latter is the chief obstacle to easy locomotion, and is the cause of the swinging or hitching gait so characteristic of the walk of those who have deformity remaining after recovery from hip-joint disease. The flexion is due to contraction of the psoas and iliacus, the adduction to the contraction of the adductors; accompanying the latter there is always a tilting of the pelvis upward upon the diseased side, and the greater the adduction the more marked the elevation of that side of the pelvis; this is necessary in order to prevent the limb upon that side from crossing over and getting in the way of the sound one in walking. The body is also twisted so as to accommodate itself to the abnormal position of the pelvis.

Adduction is a more serious deformity than flexion, and increases the real shortening of the limb, or it may be the sole cause of the apparent inequality of the limbs in walking. Fig. 2703 shows the adduction and the method of estimating the angle. In a few cases the limb is abducted.

The head of the bone and neck are often greatly altered after destructive inflammation of this joint, and are the chief cause of the actual shortening. In ankylosis after rheumatoid inflammation the head and neck are not altered, and the bond of union between the head of the bone and the acetabulum is bony. The deformity of the limb is due to position rather than to active contraction of the muscles, as is the case in hip-joint disease, and the limb may be fixed in a straight position—a condition not often found after destructive disease of the hip. The same remark applies to ankylosis after fracture near the joint.

The possibility of obtaining useful motion after operations at or near ankylosed joints is very remote, and probably has never been accomplished. It is true that in a few cases there has been motion at the seat of section for some time, which has held out the hope that a movable articulation might be obtained, but disappointment has always followed, and when we consider the condition of the parts, the attachment of muscles, and the atrophy of the limb, there is little prospect that this much-to-be-desired result can be attained. The fact that useful motion has never followed these operations, although persistently sought for, demonstrates the folly of such attempts. A much more interesting and practical question, and one that demands careful inquiry, is at what angle a limb should be placed in order to be of the most use to the patient; for, upon the proper solution of this depends the success of any operation having in view the greatest comfort to the patient. If ease in only one position was required, the answer would be a very simple one; for walking and standing, a limb ankylosed in a straight line with the long axis of the body would certainly be the best, while for sitting, one placed at a right angle would be the most useful. On the other hand, a limb ankylosed in a straight position would be the most uncomfortable for sitting, and at right angles for walking. Again, in a straight position the patient cannot put on his shoes. An angle that is a compromise between these two positions must be taken, which, while giving the greatest latitude in walking, permits of his sitting with comfort and putting on his shoes. It has been demonstrated that an angle of 130° or 135° with the transverse axis of the pelvis permits of this. Fig. 2704 is taken from a patient who recovered from suppurative hip-joint disease, with ankylosis at an angle of 130°. She is able to walk with but a slight limp, sits with ease, and can put on her shoes. Any deviation from this angle toward a straight position requires correction. The angle is obtained either by placing the patient on his back and bringing the thigh forward until the lumbar spine is flat on the couch, or by having him stand erect and then bringing the thigh up until the lordosis is obliterated, measuring the angle that the femur makes with the long axis of the body.

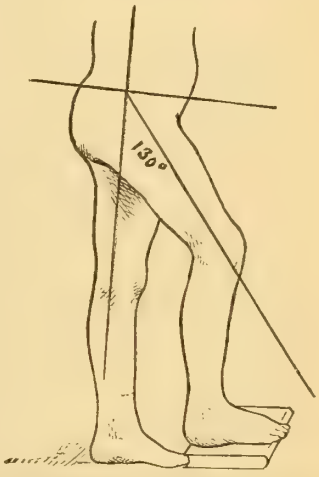


Fig. 2704.—The most Useful Angle for an Ankylosed Limb.

The object of any operation is to remove *all* the adduction and bring the femur down, so that it forms with the body an angle of at least 130°. When the flexion is at the last-mentioned angle and there is adduction, the latter should be corrected, as it will improve the ability of the patient to walk.

There are three points at which section has been made to correct the deformity occurring with ankylosis at the hip-joint, namely, through the neck, between the trochan-

ters, and below the trochanter minor. That through the neck is known as Adams's operation, and consists in dividing the neck at right angles to its long axis with a saw or osteotome. Fig. 2705 shows the line. The instruments necessary for this operation are a tenotome with a long stem and the saw known as Adams's. The operation is performed in the following manner: A tenotomy knife is entered a little above the top of the great trochanter, and carried straight down to the neck of the thigh-bone. The muscles are divided, and the capsular ligament is freely opened. Withdrawing the knife, the small saw is carried along the track made, straight down to the bone, which is divided from before backward, and at right angles to the long axis of the neck.

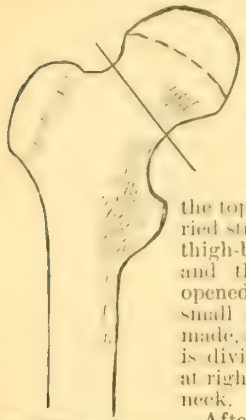


Fig. 2705.—Adams's Line of Section.

After the division is completed, those muscles that prevent the limb being brought into the desired position are divided, and the limb is put up in a straight position, the wound being covered with a compress held in position by a piece of adhesive plaster. An osteotome may be used in the place of the saw.

Operations between the Trochanters.—There are two operations performed at this point, namely, a simple section and the removal of a wedge-shaped piece of bone. The former is performed in the same way as is any linear osteotomy, while the latter is done through a large wound, and a chisel, not an osteotome, is used. Fig. 2706 shows the line of section in a cuneiform osteotomy.

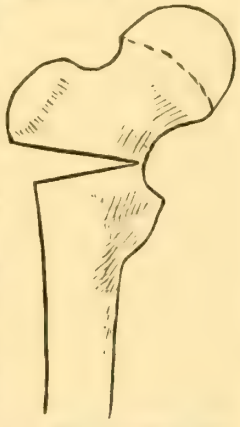


Fig. 2706.—Cuneiform Osteotomy between the Trochanters.

Section below the Trochanter Minor.—This operation is known as Gant's, and is shown in Fig. 2707. It is performed with an osteotome, and is a simple section of the femur just below the trochanter minor.

Dr. Stephen Smith has devised and carried out the following operation (*Medical Record*, June 2, 1883, p. 589): With a saw he made two partial sections of the femur, just below the trochanter minor, one from its posterior, the other from its anterior aspect, about an inch apart, and then fractured the intervening portion of bone longitudinally, thus making a half tenon and mortise, the object being to prevent any displacement of the fragments. Fig. 2708 shows the method of operation.

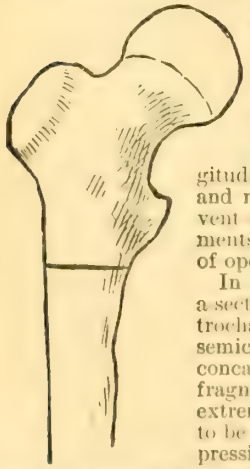


Fig. 2707.—Section below the Trochanter Minor; Gant's Operation.

In 1862 Dr. Lewis A. Sayre made a section of the femur, just above the trochanter minor, and removed "a semicircular piece of bone, with its concavity downward, from the upper fragment, and rounded off the upper extremity of the lower fragment so as to be received in this cup-shaped depression, and thus aid in establishing an artificial joint." Fig. 2709 illustrates the operation. Volkmann, in 1873, removed a wedge-shaped piece of bone from below the trochanter major in order to correct the adduction of the limb in bony ankylosis. Later he substituted an excision of the joint with a chisel and gouge, a linear osteotomy being first performed, and then the head and neck were removed in pieces.

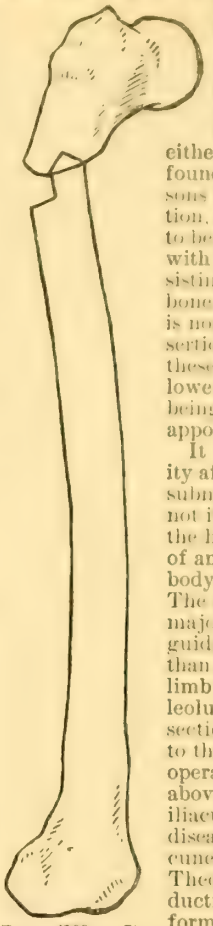


Fig. 2708.—Stephen Smith's Line of Section.

Choice of Operations.—The presence of a neck is an absolute necessity in an Adams's operation. In many cases, after disease of the hip-joint the head and neck have either entirely disappeared or are profoundly altered. For pathological reasons this point is not a good one for section, as the operation would often have to be performed through bone infiltrated with inflammatory products of low resisting power, or through sclerosed bone. The danger of secondary trouble is not slight. Again, it is above the insertion of the psoas and iliacus, and these muscles being still attached to the lower fragment, will prevent the flexion being overcome, and lead to much disappointment in the final result.

It is a question whether any deformity after hip-joint disease should ever be submitted to this operation—certainly not if there are any marked changes in the head and neck of the femur. Cases of ankylosis in a straight line with the body are proper ones for this operation. The height of the top of the trochanter major above Nélaton's line is a better guide, as to any change in the neck, than the amount of shortening of the limb, measuring from the internal malleolus to the anterior superior spine. A section between the trochanters is open to the same objection as is an Adams's operation; the point of division being above the insertion of the psoas and iliacus, and near the point of former disease. There is no advantage in a cuneiform over a simple osteotomy. Theoretically it would seem that the adduction could be easier corrected by the former, but practically a simple section will accomplish all that is required; besides, a cuneiform osteotomy is done through a large wound, is a more difficult operation, and requires more cumbersome dressings.

Section below the trochanter minor is not open to any of the objections mentioned above. After division, the limb is entirely under the control of the operator, and the danger that flexion may not be overcome to a sufficient degree is reduced to a minimum. A simple osteotomy, if the after-treatment is properly carried out, will accomplish all that is desired, and there does not seem to be the least necessity for the removal of a wedge-shaped piece of bone. The method adopted by Dr. Stephen Smith, as well as that of Volkmann, has no advantage over a simple section.

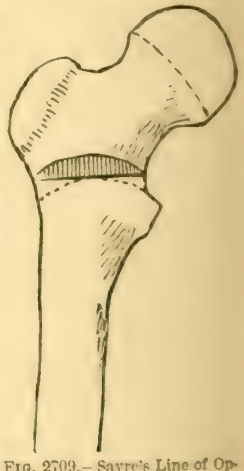


Fig. 2709.—Sayre's Line of Operation.

Cases of partial fibrous anchylosis with motion, and of deformity due to contraction of the flexors and adductors, are not suitable cases for an osteotomy, as the deformity is sure to return as soon as the patient begins to use the limb, for the muscles contract further, and the same condition is produced as before the operation.

Treatment of the Limb.—After the section is completed

the limb should not be twisted in various directions, in order to stretch the muscles and break down any adhesions that may exist. Nor is there any necessity to divide any muscle that may be tense. After the wound has been dressed, a long splint is applied, extending from the axilla to the ankle, and the patient put in bed. An extension weight of from four to six pounds is applied to the limb, and the weight should be increased within the next two or three days until the muscles and adhesions have been thoroughly stretched, and the limb well brought down. It will then be found that the limb can be placed in any desired position without any pain to the patient. The extension can now be slackened a little, and the after-treatment is the same as that for a simple fracture. The patient should under no circumstances be allowed to sit up in bed, and the long splint must be kept on until consolidation is complete. Care should be taken that the adduction is completely corrected. The position of the anterior superior spines of the ilium is the best guide; if these are upon the same plane adduction cannot exist. The position of the limbs is not a trustworthy indication of the absence of adduction, for the limbs may be parallel owing to an elevation of the pelvis on that side, yet adduction to a marked degree may be present. A little abduction is not a disadvantage. In very rare cases after hip-joint disease the limb is abducted besides being flexed; if this is marked it is a difficult deformity to overcome, from the fact that, the pelvis being depressed, any extending force tends to increase the lowering of the pelvis on that side. The best way to correct it is to strongly adduct the limb by raising it and drawing it over the sound one. The writer of this paper has met with only one example of this deformity. The abduction was marked, and was only corrected by resorting to the method mentioned above. Fig. 2710 shows the amount of flexion; Fig. 2711 the abduction; Fig. 2712 the result as to flexion—the abduction was reduced to eight degrees.

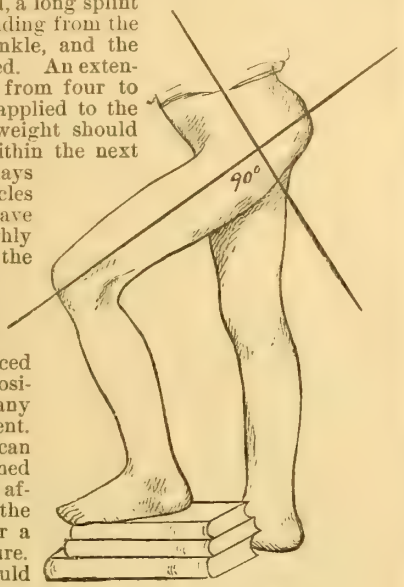


Fig. 2710.—Showing Flexion.

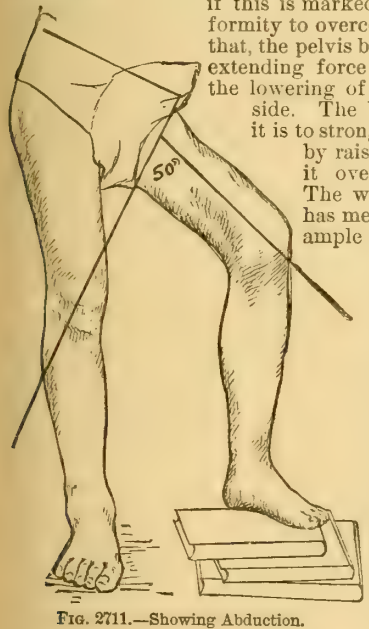


Fig. 2711.—Showing Abduction.

The accidents following section at the upper end of the femur are injury to the vessels, necrosis, and suppuration. Post reports a case in which he made a section, below the trochanter minor, through a large wound. The limb became gangrenous and the patient died; the cause of the gangrene was pressure upon the vessels by the upper fragment.

Servias reports a case of profuse hæmorrhage from the femoral, or one of its large branches, on the twentieth day after an Adams's operation. The femoral was ligated and the patient recovered. Suppuration and necrosis have followed in a few cases. After an Adams's operation the head has been necrosed in several cases. There have been 17 fatal results reported out of 167 cases operated upon. In 68 cases of division of the neck, 3 died from pyæmia, 3 from extensive suppuration and exhaustion, 1 from tuberculosis. In 64 cases of section below the trochanter (linear osteotomy), 1 died from collapse, 1 from return of the disease, 3 from pyæmia, and 1 from suppuration and exhaustion. In 35 cases of cuneiform osteotomy, 2 died from Bright's disease, 1 from exhaustion, 1 from tuberculosis, and 1 from embolism. The mortality being 10.67 per cent. Of these fatal cases 12 occurred prior to 1877, and only 5 after that date, although the cases are very nearly equally divided in these two periods. Section of the upper end of the femur, in appropriate cases, and when properly performed, should not be more fatal than a simple fracture in the same locality; in fact, it should be less so, because there is an entire absence of traumatism, and the operation is performed under the most favorable conditions. Cases are upon record where a section through the neck has failed to correct the deformity, and a division below the trochanters, subsequently performed, has been followed by good results.

Osteotomy of the Shaft of the Femur.—This has been done for fractures of this bone that have united at an angle. Most of them were performed before the present methods of operating and wound management were known, and were accompanied by a high rate of mortality. The few cases that have been operated upon of late years have done well. If there is much overriding of the fragments, a wedge of bone has to be removed. As there is nothing special about these operations, the same rules will apply as for osteotomy in other portions of the body. Osteotomy is sometimes required for marked rachitic curvature of the femur.

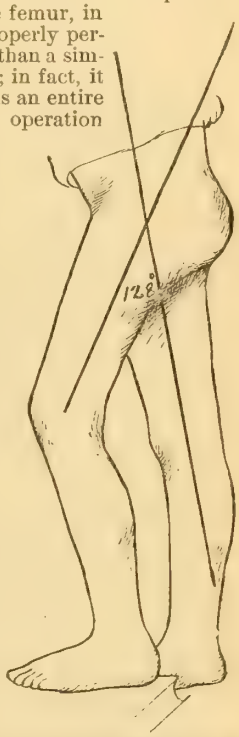


Fig. 2712.—Showing Result as to Flexion.

Osteotomy for Genu Valgum.—Genu valgum is a deformity about the knee-joint in which a line drawn from the head of the femur to the middle of the ankle-joint passes outside of the centre of the knee, and in which the internal malleoli cannot be made to touch when the limb is fully extended. The cause of this deformity is due to actual or relative changes taking place in the articular ends of the femur and tibia. There are three varieties—namely, a femoral, a tibial, and one in which alterations are found in the ends of both of these bones.

The femoral variety is due to a real or apparent depression of the internal condyle of this bone, so that it occupies a lower position in relation to the external condyle than in the normal limb. It has for its cause an actual hypertrophy of the internal condyle, a tilting downward of the internal and an elevation of the external condyle, due either to a curvature in the lower end of the femur or a twisting of the epiphysis in the diaphysis, or to an atrophy or flattening of the external condyle. It has been caused by a diastasis at the lower end of the femur. The tibial variety is due to corresponding changes taking place in the head of the tibia. The articular ends of both bones may be changed and each contribute to cause the deformity.

Much has been said in text books on the influence of the ligaments in bringing about the deformity. They are sometimes relaxed, sometimes the internal at other times the external ligament is elongated, while in other cases the articular surfaces are held firmly in position. From this it is evident that the ligaments can have no influence upon the causation of the malposition of the tibia. In the vast majority of cases genu valgum is of rachitic origin, and its advent therefore belongs to the earlier years of life. The deformity may be simple or complicated, with curvature of the femur or tibia, or both bones may be changed in shape.

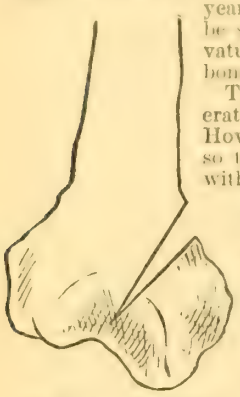


Fig. 2713.—Ogston's Line of Section.

The problem to be solved in the operative treatment of genu valgum is, How can the tibia be swung inward so that its long axis will correspond with that of the femur? It is evident that this can only be accomplished by relatively or actually raising the plane of the internal condyle or depressing that of the external, or causing corresponding changes in the head of the tibia.

There have been two classes of operations performed, namely, operations upon the condyle and operations upon the shaft of the femur.

Operations upon the Condyle.—Ogston, in 1876, carried out the following operation: After the patient was well under the influence of ether and the limb rendered bloodless, the leg was flexed on the thigh as far as possible, the femur being rotated outward. A long tenotomy-knife was introduced, three and a half inches above the tip of the internal condyle, on the inner side of the thigh, and so far back as to be opposite the ridge running between the linea aspera and the condyle. Its blade was then carried forward, downward, and outward, over the front of the femur, with its cutting edge directed to the bone; when its point could be felt under the skin in the groove between the condyles, where the patella would normally have been lying, the cutting edge was pressed against the bone, and the soft parts divided with a slow movement in withdrawing the knife. The external wound thus made was about one-third of an inch long, and formed the entrance to a subcutaneous tunnel running obliquely over the front of the femur and ending in the cavity of the joint. An Adams's saw was then introduced into the tunnel, and the condyle sawn off by directing the edge of the instrument straight backward. When it was estimated that the edge of the saw had arrived near the popliteal space it was withdrawn, the knee completely extended, and with the hands and the operator's knee as a fulcrum, the patient's knee was then forcibly straightened by bending the leg inward, the remaining connections of the condyle with the femur giving way with a crack on the application of a very moderate force, and instantly the leg becomes straight. The whole operation was performed under strict antiseptic rules, and the limb was put up in splints in a corrected position. Fig. 2713 shows Ogston's line of section.

Fig. 2714.—Reeves's Line of Section.

Reeves has modified Ogston's operation as follows: A scalpel is introduced obliquely, just above the tubercle for the attachment of the tendon of the adductor magnus, and the soft parts and periosteum are divided on the line of Ogston's section, the length of the wound in the soft parts being long enough to easily admit the osteotome. This instrument is then introduced, and, commencing on the ridge of bone going from the tubercle for the attachment of the tendon of the adductor magnus to the linea aspera, is driven downward and outward toward the inter-condyloid notch, the bone being divided only as far as the cartilage on its articular surface. The condyle is then loosened by using the osteotome as a lever, and is separated completely by forcibly straightening the limb, which is at once put up in a permanent dressing. Fig. 2714 shows the extent of the division of the bone in the operation. It has been claimed for this operation that the joint is neither entered by the osteotome nor broken into by fracture, but it is probable that only the first statement is true, and that the joint is always entered in the process of sliding the detached condyle upward.

Fig. 2715.—Chiene's Line of Section.

In 1879 Mr. Chiene proposed and carried out the following operation for raising the plane of the internal condyle: The tubercle to which the tendon of the adductor magnus is attached is first located. An incision two or three inches in length is made over the tubercle and in the long axis of the limb, the incision commencing half an inch below the tubercle and being carried upward. After the division of the skin and fascia, the tendon of the adductor magnus is exposed. The operator passes in front of the tendon, between it and the fibres of the vastus internus, when the bone, covered by periosteum, is exposed. The latter is incised and turned aside. With a chisel and mallet a wedge-shaped piece of bone is removed from the base of the condyle immediately above the tubercle. The breadth of the wedge will depend upon the amount of the deformity. The long axis of the wedge runs downward and outward toward the notch between the condyles. "The wedge is at a higher level than the epiphyseal line." The external condyle is then displaced upward (see Fig. 2715).

Macewen performed an operation somewhat similar to Chiene, except that he removed the wedge in Ogston's line (Fig. 2716).

All of these operations upon the condyle are theoretically correct in those cases in which the internal condyle is hypertrophied, but they all have the objection that the epiphyseal cartilage is divided and the joint entered; if this is not done by the instrument, the articulation is usually invaded at the time when the internal condyle is displaced upward. The danger, however, to the integrity of the joint is slight; generally no inflammation has followed these operations. The great danger is to the epiphyseal cartilage. There are now four cases on record in which arrest of growth, if not atrophy of the internal condyle has followed incision into it, leaving the limb in a much worse condition than with the deformity for the correction of which the operation had been performed. Operations through the epiphyseal line have now been abandoned, and section above this been substituted.

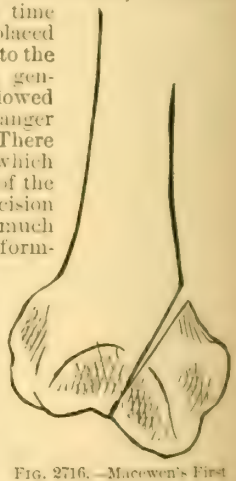


Fig. 2716.—Macewen's First Operation.

Operations upon the Shaft.—Macewen, in 1877, corrected a case of genu valgum by making a section just above the line of the lower epiphysis of the femur in the following manner: The limb being rendered bloodless, and the leg fully extended upon the thigh, an incision was made on its inner side at the point where a line drawn transversely a finger's breadth above the superior tip of the external condyle was met by one drawn longitudinally half an inch in front of the adductor magnus tendon. Fig. 2717 shows the line of division. An osteotome was then passed down to the bone, and the latter divided until the exter-

nal shell was well cut into, then the remaining portion was fractured by bending the leg inward. A modification of the rule for determining the line of section seems to the writer an advantage. With the limb fully flexed, make the incision at a point a finger's-breadth above the superior tip of the internal condyle and on the ridge of bone running from the tubercle for the attachment of the tendon of the adductor magnus to the linea aspera. The latter point is easily found, the vessels are farther out of the way, and when the limb is again extended the incision in the skin does not correspond with that in the deeper tissues. The wound is to be treated as described elsewhere, and the limb put up in an over-corrected position. Reeves has advocated a section of the femur through its middle, but the operation has never met with much favor, and is seldom performed. Some operators make the section from the outer side.

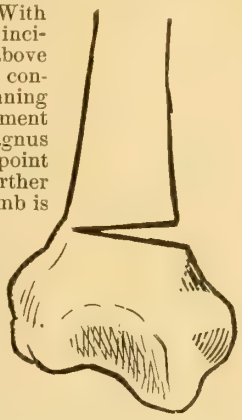


FIG. 2717.—Macewen's Second Line of Section.

Barwell has advocated a double division. He first makes a section in Macewen's line and corrects half of the deformity, and after consolidation has taken place makes a division of the upper part of the tibia and corrects the rest. In a few cases of very marked genu valgum a Macewen operation will not correct all the deformity, and in these cases a second osteotomy of the tibia may be necessary, but, as a rule, a division of the femur will be all that is required.

The accidents occurring during or after osteotomies about the knee-joint are few. The popliteal artery has been divided once during the operation, and in two cases was perforated by a spiculum of bone, in two cases the anastomotica magna has been divided, once the condyle was fractured longitudinally into the joint. This was probably due to an improper use of the osteotome, driving it in after it had become fixed, thus causing it to act as a wedge. Suppuration has been infrequent, and when it has occurred has probably been due to improper treatment of the wound. There are, however, some cases of abscess for which no cause can be assigned. In a few cases there has been a slight exfoliation of bone. From the operation itself above the condyle, when it has been carefully performed and when the wound has been properly managed, a fatal issue has not been recorded. Those deaths that have occurred were due to preventable causes and belong to the early history of the operation. After operation upon the condyles stiff joints have been reported, but none after section above the condyles.

Osteotomy for Ankylosis of the Knee-joint.—Linear osteotomy has been practised for angular deformity with ankylosis of the knee-joint. The point of section in a few cases has been through the joint, but in the majority of cases it has been made just above the epiphysis, after which the limb was put up in a straight position. A cuneiform excision of the whole joint is the better operation.

Osteotomy for Curvature of the Tibia.—Tibial curves may be either rachitic, traumatic, or pathological. The vast majority of cases of bending of the bone come under the first class. The deformity may be lateral, anterior, or antero-lateral. Any part of the bone may be the seat of the change, or it may involve the whole shaft. In anterior curvature the bone seems elongated in its anterior aspect and sometimes overhangs the foot. Traumatic curvatures have their origin in fractures which have united at an angle. Pathological curvatures are those in which there is a bending of the bone from some local cause; many of them are syphilitic. The bone may become deformed after necrosis near the epiphyses.

Treatment of curvature of the tibia varies with its cause. In rachitic deformities much can be done for lateral curves, while the bones are soft, by mechanical means, but after sclerosis has taken place splints are worse than useless. The age at which the bones become hard in rachitic children varies in different individuals. I have seen exceedingly hard bones in children of three years of age, and, on the other hand, quite soft bones in those of ten years. It is not a question of years, but of nutrition.

Lateral curves of rachitic origin may be corrected by osteotomy or osteoclasis. For the method of using the latter, the reader is referred to the article on that subject.

Osteotomy for the Correction of Rachitic Curves.—All lateral and antero-lateral curves of slight degree may be corrected by a linear osteotomy; anterior curves must be submitted to a cuneiform osteotomy. In all cases the fibula must be divided first, a narrow osteotome being used and the section being made from below, upward and inward. In performing the tibial section the incision should be made down upon the crest of the bone at its point of greatest curvature. In using the osteotome it is safest to divide in the direction from without inward, commencing on the crest; care should be taken that the end of the instrument does not project beyond the outer border of the crest, as if this is done there is danger of wounding the anterior tibial artery. After the bone has been divided throughout its greatest extent, the fracture is completed by bending the bone inward, and the wound is treated as detailed elsewhere. The plaster dressing should extend up above the knee. For an anterior curve a cuneiform osteotomy should be performed, the section being made at the point of greatest curvature. In many cases the tendo Achillis must be divided in order to allow the lower fragment to be brought into position.

Division of other long bones than those mentioned above may be called for to relieve deformities after fracture, but as there is nothing peculiar about the operation or the after-treatment, it requires no further notice.

Osteotomy for deformities of the foot merits special attention, on account of the various opinions both in regard to its necessity and as to the point of operation. There are two deformities of the foot for which an osteotomy has been performed, namely, talipes valgus and varus. As the causes of these two malpositions, as well as their operative treatment, are entirely different, they cannot be considered together.

Osteotomy for Congenital Talipes Varus.—Many theories have been put forward as to the cause of this deformity; the one which is now generally adopted by surgeons is that of an exaggeration or the persistence of the infantile forms of the neck of the astragalus. It is an anatomical fact that the neck of this bone in infants at term is set upon the body at a mean angle of 38°, while in the adult bone the mean angle is only 10.65°, but in congenital equino-varus the mean angle is 49.6°, the maximum being, according to Parker and Shattock, 64°, the minimum, 31°.

In some cases, probably the majority, if the deformity is at all marked, the anterior part of the os calcis is curved from before backward, the convexity being directed outward, and its anterior articulating surface looks forward and inward. The ligaments upon the inner aspect of the foot are shortened on account of the approximation of these points of insertion, and thus hold the head and neck of the astragalus in its infantile, or exaggerated infantile position, so that it cannot undergo rotation and tend to assume the shape of the adult bone. The pathological changes found in the majority of cases of congenital talipes equino-varus may be described as an exaggerated obliquity of the neck of the astragalus and curvature of the anterior portion of the os calcis, together with its elongation, while the head of the astragalus is held in its abnormal position by short ligaments; the scaphoid is carried upward and inward by the head of the astragalus and held there by the abnormal condition of the ligaments; the muscles have nothing to do with its causation, nor do they act as much of an obstacle to the restitution of the foot. Exception should, however, be made to muscles entering into the formation of the tendo Achillis.

It is evident from an examination of the foot in a case of this deformity that the cause of the abnormal position

of its anterior segment is not in *front* of, but *behind*, the medio-tarsal joint, and that in congenital varus, as a rule, the angle at which the neck is united to the body of the astragalus is increased, so that the neck is set upon the body at an angle of 64°. In the astragali of eleven infants with this deformity the mean angle was 49.6° (Parker and Shattock, "Trans. London Path. Soc.," 1884). In a case seen by the writer the angle was 55°, and in those which have been submitted to an operation the neck of the astragalus has always been found elongated. The anterior portion of the os calcis in marked cases of this deformity is curved from before backward, the convexity being directed outward, and its anterior articulating surface looking forward and inward; it also extends farther forward than in the normal bone, and is therefore elongated. The ligaments on the inner aspect of the foot are shortened on account of the approximation of their points of insertion, and these are the anterior portions of the internal lateral ligament of the ankle-joint, the astragalo-scaphoid, the calcaneo-scaphoid, and also the inner portion of the plantar fascia. These hold the navicular bone and the head of the astragalus in their infantile or abnormal position, and prevent the neck of the astragalus from undergoing the rotation incident to normal growth.

Of the many operations that have been resorted to in order to relieve this deformity in those cases in which mechanical treatment, stretching, tenotomy, etc., have failed, all but one have been abandoned. Many of them left the foot in a worse condition than before the operation, and in a few amputation had to be performed, while in others an apparatus had to be worn to enable the patient to get about. The operation which has yielded the best results is that known as Devys's. It consists of removing a wedge of bone, base outward, from the tarsus, without regard to any particular bone. It invariably includes portions of the os calcis, cuboid, astragalus, and scaphoid bones. In one case he removed a portion of the os calcis, the head of the astragalus, the whole scaphoid, and part of the cuboid bone. By this operation the foot is much shortened and many of the tarsal joints are destroyed; the patient walks, it is true, on what remains of the plantar surface of his foot, but with all the tarsal joints, except the ankle and those in front of the front row, ankylosed.

If the statement made above is correct in regard to the condition of the bone in this variety of club-foot, it is evident that the real deformity lies not in *front* of, but *behind*, the medio-tarsal joint, and that all operations upon the bones in front of this point are anatomically and mechanically wrong. From a study of the subject the following points suggest themselves:

1. The inability to correct the deformity is due to changes taking place in the astragalus and os calcis.

2. In order to bring the anterior portion of the foot into its normal position the curvature in the os calcis must be removed and the neck of the astragalus shortened, so as to allow its head to point in the normal direction and thus carry with it the scaphoid and other tarsal bones.

To accomplish this, the following operation may be performed: An incision is made from a point one inch and a half in front of the tendo Achillis, on the outer aspect of the foot, forward to the middle of the cuboid bone, and down to the tendons of the peroneus longus and brevis; these should be raised or pushed out of the way. Another incision, beginning from the middle of the first and corresponding to the neck of the astragalus, is made directly upward; the tissues are then raised from the bones and the periosteum incised over that part of the os calcis from which it is desired to remove the wedge. With a chisel a V-shaped piece of bone, with its apex extending to the inner border of the os calcis, is taken away; a wedge is then removed from the neck of the astragalus of such a shape as to allow the anterior portion of the foot to be brought outward and upward. The periosteum is united with catgut, and the skin with several wire sutures, because the latter hold longer and give better support. An aperture is left posteriorly for the insertion of a drainage-tube; a plaster-of-Paris bandage is applied, extending from the toes to above the knee, and the foot is placed in a corrected position; the wound is dressed with iodoform and gauze.

The size of the V shaped interval left after the removal of the wedge of bone should be sufficient to allow the anterior portion of the foot to be placed in a proper position without any tension of the tissues on its inner aspect. I think that a subcutaneous division of the ligaments on the inner border of the foot, when they are tense, would facilitate the correction.

The dressings should be as light as possible, not bulky, otherwise it will be found difficult to apply the plaster-of-Paris bandage firmly; a little over-correction does no harm.

The advantages claimed for this operation over that of removing a wedge from in front of the medio-tarsal joint are:

1. It is anatomically and mechanically correct.

2. A smaller amount of bone has to be removed, because the operation is performed nearer the apex of a triangle.

3. No joint is opened, and, consequently, the foot is left in a more normal condition.

4. It does not practically shorten the foot in front of the ankle-joint.

The classes of cases suitable for this operation are:

1. Those of patients who have reached the age of five or six years with the deformity unrelieved, who have walked on their feet, and in whom the parts are rigid and the deformity marked.

2. Those which, although the anterior portion of the foot can be brought into place, yet require an apparatus to retain the foot in its normal position after years of careful treatment.

3. Those in which the obstacle to restitution is due to elongation of the os calcis: perhaps in these patients the removal of a small wedge from that bone would accomplish the result.

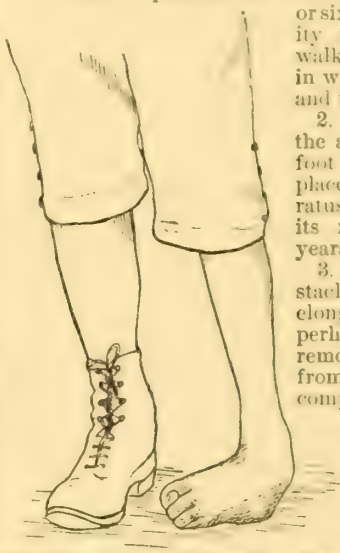


Fig. 2718.—A Case of Talipes Varus in a Boy Eleven Years of Age. Before Operation.

After mechanical treatment of this deformity there often persists an inward curve of the anterior portion of the foot. This is due to the elongation of the os calcis not having been corrected. After the operation detailed there is no tendency to turn inward, and the foot is planted firmly on the ground. Figs. 2718 and 2719 show a case of the deformity before and after treatment.

The pathology of talipes valgus, or flat foot, differs from that of varus in that the deformity is mainly confined to the inner aspect of the foot, and consists of a sinking down or obliteration of its inner arch. All the tissues that contribute to maintain the foot in its normal position when the body is erect, become affected, but in different degrees. The bones, ligament, and tendons that hold the instep up are so modified that the arch is unfolded, its two extremities recede from one another, and its curve, finally, becomes a straight line, touching the ground along its whole length. The chief cause of this is a lengthening or stretching of the calcaneo-scaphoid ligament. Owing to this giving way of the ligament the under aspect of the articulating surface becomes separated, while on its upper side the pressure is increased. True growth is checked or absorption takes place, while at the lower portion of the articulation, where pressure is diminished, there is often an increase in growth, so that in time the shape of the head of the astragalus is changed

to accommodate itself to its altered relations. Secondary to the changes at Chopart's joint the foot is everted, the metatarso-phalangeal joint of the great toe appears prominent, and the toe itself gradually turns outward. The tissue most at fault is the calcaneo-scaphoid ligament, the relaxation of which allows the head of the astragalus and the scaphoid to sink downward; the more this is lengthened the greater will be the deformity, and more unsatisfactory the mechanical treatment. In the author's experience, except in slight cases occurring in young children, the deformity is very intractable to treatment by braces, supports, or exercise. The difficulty is to hold up the arch and at the same time to strengthen the relaxed ligament. It is, moreover, a deformity, if at all marked, which prevents the patient from standing and walking much, on account of the pain. The indication in the treatment of this condition is to raise and hold in position the arch of the foot. If this cannot be accomplished by exercise and apparatus an operation is called for. Ogston, in 1877, began his efforts directed to the relief of this deformity by producing ankylosis of Chopart's joint. He first put the foot up in plaster-of-Paris in a corrected position, and then injected carbolic acid into the tissues so as to get up an inflammation, and thus stiffen the parts, but the result was not satisfactory. He then opened the joint between the astragalus and scaphoid and removed the articular cartilage from a small portion of each bone. Although the condition of the foot was improved, there was still some motion at this articulation. Langenbeck forcibly reduced the deformity and then applied a fixed dressing.

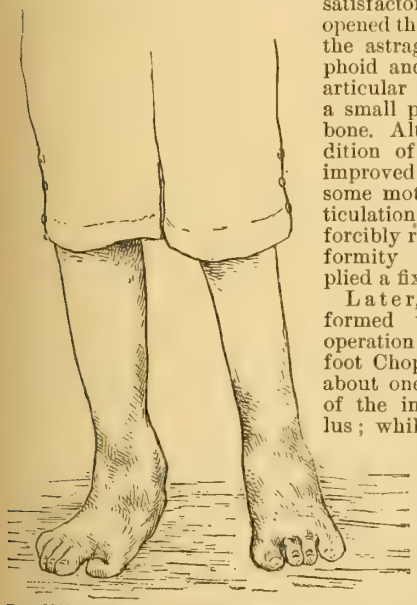


Fig. 2719.—After a Cuneiform Osteotomy of the Os Calcis and Head of the Astragalus in a Case of Talipes Varus.

Later, Ogston performed the following operation: In the normal foot Chopart's joint lies about one inch in front of the internal malleolus; while in a case of talipes valgus it lies half an inch farther forward. He made an incision one and one-fourth inch long, parallel with the sole of the foot, and over the articulation between the astragalus and scaphoid, dividing all tissues down to the bone. The capsule of the joint was then divided and retracted so that ready access could be obtained. With a chisel the articular cartilage was removed from the head of the astragalus and from the cup-shaped depression on the scaphoid in such a manner that the cancellous structure of both bones was exposed, so that when the arch was restored the bones would come accurately together. In old cases more should be taken away from the under surface, in order to remove the hypertrophied portion of the head of the astragalus. He then inserted ivory pegs so as to hold the two surfaces together, and put up the foot in a fixed dressing. The patient was not permitted to use the foot for eight weeks. The use of ivory pegs can be dispensed with by strongly adducting and rotating upward the anterior portion of the foot, in other words, bringing it into a varus position. This will bring the bones together and restore the arch. Ogston (*Lancet*, January 20, 1884) reports seventeen feet operated upon in this way, and in which good results were obtained. The operation has been performed by other surgeons with success.

Osteotomy has been looked upon as a serious operation, not to be undertaken except in extreme cases. That this is an error is evident from the results published in general works and in the medical journals. It is not more serious in its results, if performed properly and in appropriate cases, than simple fracture of the same bone in the same locality. As stated before, the fatal cases belong to the early period of the operation. Many of them occurred after section of bone for angular deformity following fracture, and were performed through large wounds, and not antiseptically.

Beauregard has collected 2,037 cases, extending over forty years; of these there were 67 grave complications, as profuse suppuration, necrosis, etc., and 44 deaths, a percentage of 2.1. In some statistics collected by the writer ("Osteotomy and Osteoclasis"), comprising 1,510 cases of osteotomy for the correction of deformities at the hip-joint, for genu valgum, and tibial curvature, there were 22 fatal cases, a mortality of .0132 per cent. When one considers the large number of operators, their inexperience, and the faulty methods of operation and of wound treatment, these results speak well for the safety of the procedure, and with proper care the mortality should not be greater than that following any of the minor operations of surgery.

Charles Talbot Poore.

OTOLOGY, MEDICAL. The expression used here is intended to refer to the treatment of affections of the ear by means of remedies which are administered by the mouth. Such remedies are spoken of as constitutional or general remedies, in contradistinction to those which are applied locally to the ear or to its correlated parts. Practical otology is almost wholly surgical in its nature. It has for its object the removal of mechanical obstacles or the overcoming of mechanical defects, the arrest of inflammation, the diminution of swelling resulting from inflammation, the arrest and healing of ulcerative processes, the overcoming of vaso-motor paresis, and, finally, the removal, by absorption or by excision, of new-growths. This, I believe, is a complete epitome of the work which the practical otologist is called upon to perform. As will be seen at a glance, purely local surgical interference will suffice for the accomplishment of nearly all the objects which I have enumerated. A syphilitic new-growth must, as a matter of course, be combated by the administration of constitutional remedies. Even if the new-growth be within sight and reach, no purely surgical interference will produce effects comparable with those which may be obtained by constitutional treatment; and, when the growth is presumably located in the labyrinth or at one of its outlets, or at any other point which is out of sight and out of reach, we are forced to depend exclusively upon the constitutional remedies—mercury and one of the combinations of iodine. So far as I know, there are no other pathological conditions of the ear which necessarily demand medical treatment; or, to state the case somewhat differently, there are no other affections of the ear in which purely surgical treatment will not accomplish the desired results more quickly and more perfectly than constitutional measures can. On the other hand, it must be admitted that there are constitutional remedies which play a very useful part in promoting the success of surgical interference, or which even may be trusted to effect a cure where surgical means are not obtainable. Thus, for example, cod-liver oil may well be placed at the head of the list of those remedies which possess the power to check, or even cure, an obstinate catarrhal inflammation of the middle ear, especially in children. No other remedy known to me can take its place, unless it be that remarkable influence exerted by travel, involving as it does a change of climate, scene, diet, etc. Calomel, or the mild chloride of mercury, unquestionably exerts, when introduced into the circulation, a restraining or even a curative action upon a violent acute inflammation of the middle ear. In infants and young children its good effects are sometimes very striking. It is claimed by certain authorities that calcium sulphide exercises a similar restraining influence. The evidence in

regard to the efficacy of this drug is conflicting; indeed, much of the evidence put forward by those who praise the drug so highly is susceptible of a different interpretation. Opium, belladonna, and now and then even aconite are used, not simply for the purpose of quieting pain, but with a view to their restraining effects upon the progress of an acute inflammation. The aural surgeon is not the proper person to pass judgment upon the efficacy of any of the four drugs last named, for the simple reason that he has in his arsenal more potent weapons with which to combat inflammation and to relieve pain. These are discussed on p. 580, of vol. ii., and nothing further need be said in this place in regard to them. Some German authorities claim that by the internal administration of oil of turpentine a purulent discharge from the middle ear may be greatly diminished, or even arrested completely. There are undoubtedly cases in which this remedy—if we concede to it the virtues which are claimed for it—might be administered with decided advantage. I refer particularly to cases in which the perforation in the drum-membrane is very small—too small, in fact, for adequate medication of the cavity beyond—or is located in the region spoken of as Shrapnell's membrane. Few, however, will feel like taking the risk of substituting a renal affection for a purulent inflammation of the middle ear, so long as it is possible to adopt other and safer measures for the relief of the latter disease.

In the next place, in certain cases of tinnitus aurium, and also of impaired hearing, in which it is assumed that the source of irritation is located in the nerve of hearing, either within the labyrinth or between this point and the auditory centre in the brain, various drugs are lauded as possessing curative virtues. Such are strychnine, the iodide of sodium or of potassium, hydrobromic acid, bromide of sodium or of potassium, nitrite of amyl (taken by inhalation), pilocarpine (hypodermatically), and perhaps iron and quinine in anæmic states. In isolated instances all these remedies have apparently produced beneficial results, but these cases are so few in number that the physician resorts to their employment with but little expectation of obtaining any satisfactory results.

It is not unlikely that arsenic may be used to advantage in certain states of the ear, and the same is true of the muriate of ammonia, especially in cases of accumulation of stringy mucus in the middle ear. Personally I have very little faith in the efficacy of these drugs.

Finally, medical otology is not restricted to the administration of drugs with the purpose of bringing only a *direct* influence to bear upon some part of the ear. In the general conditions known as gout, lithæmia, and eczema, and in the various disorders of the stomach, liver, and intestines—and possibly even of more remote organs like the ovaries, the uterus, and the bladder—the administration of drugs for the relief of these disorders may be referred to in these particular instances as *indirect* medication of the ear; and such indirect use of constitutional remedies is often one of the most effective procedures in medical otology.

The opposite side of the question has been very ably stated by Dr. Samuel Theobald, of Baltimore, Md., in an article which appeared in *The Medical News* of February 4 and 18, 1882 ("The Use of Constitutional Remedies in the Treatment of Ear Diseases").

Albert H. Buck.

Climate of Ottawa, Ont.—Latitude 45° 26′ *N., Longitude* 75° 41′ *W.—Period of* 1872 to 1886 (*broken periods*).—*Elevation above Sea-level*, 200 *feet.*

	A			AA	B		C	D	E		F		J
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Range of temperature for period.
	7 A.M. Degrees.	2 P.M. Degrees.	9 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.
January	6.6	15.0	10.3	10.6	21.2	3.8	23.1	1.0	53.1	24.7	−10.9	−33.0	86.1
February	6.5	17.9	12.3	12.3	18.8	4.4	32.5	2.5	50.9	31.7	−17.5	−30.9	81.8
March	13.7	26.8	20.7	20.5	25.5	12.2	31.5	12.2	55.1	35.7	6.8	−32.0	87.3
April	34.2	46.8	38.3	39.4	45.1	30.2	50.6	28.9	79.8	60.0	23.0	0.5	79.3
May	49.7	63.4	53.6	55.1	59.4	51.0	66.9	50.6	91.7	75.0	34.9	24.0	67.7
June	60.5	73.5	62.7	64.9	70.1	60.8	78.3	56.2	96.3	76.5	46.3	34.7	61.6
July	64.2	76.5	66.7	68.5	71.4	66.1	80.4	58.0	95.9	85.0	52.4	42.1	53.8
August	60.8	74.8	63.6	65.7	72.2	62.4	78.6	63.0	98.5	83.0	49.6	34.1	64.4
September	51.3	65.4	55.2	56.8	62.7	54.8	68.0	46.9	91.9	79.4	40.5	29.2	62.7
October	40.5	51.8	43.8	45.0	52.8	40.4	54.3	33.7	80.4	63.5	29.2	17.0	63.4
November	27.4	33.8	29.1	29.9	34.3	22.4	36.8	24.1	67.7	42.7	19.2	−22.9	90.6
December	12.1	18.4	14.9	15.1	21.8	9.0	23.5	7.5	55.2	35.9	−8.2	−30.9	86.1
Spring	.....	.....	.....	38.3	43.0	24.3	.....	.....	.....	.....	.....	.....	123.7
Summer	.....	.....	.....	66.4	71.5	65.0	.....	.....	.....	.....	.....	.....	68.4
Autumn	.....	.....	.....	43.9	46.9	39.5	.....	.....	.....	.....	.....	.....	114.8
Winter	.....	.....	.....	12.7	17.7	6.6	.....	.....	.....	.....	.....	.....	88.2
Year	.....	.....	.....	40.3	42.7	37.8	.....	.....	.....	.....	.....	.....	131.5

	K	L	M	N	O	R	S
	Mean relative humidity.	Average number of fair days; clouds 4 to 7 inclusive.	Average number of clear days; 0 to 3 inclusive.	Average number of fair and clear days.	Average fall of rain and snow.	Prevailing direction of wind.	Average velocity of wind.
	Per Cent.				Inches.	From	Miles.
January	88	10.2	7.5	17.7	2.81	NW., NE.	8.1
February	88	9.5	7.2	15.7	2.52	NW.	7.9
March	83	9.2	7.5	16.7	3.02	NW.	7.3
April	72	11.0	10.2	21.2	3.51	NE.	6.0
May	67	12.5	9.3	21.8	2.80	NW., SE.	6.4
June	72	13.7	10.7	24.4	2.08	W., E.	4.9
July	76	14.0	8.0	22.0	1.90	SW., E.	5.9
August	77	13.3	12.3	25.6	3.81	W., NW.	5.8
September	80	11.0	8.7	19.7	2.81	W., NE.	5.9
October	82	9.7	6.5	16.2	2.73	NW., E.	5.1
November	86	12.3	3.5	16.0	2.50	W.	7.3
December	88	8.0	4.2	12.2	3.31	W., NW.	7.0
Spring	74	32.7	27.0	59.7	7.13	NW., E.	6.6
Summer	75	41.0	31.0	72.0	5.79	W., E.	4.9
Autumn	82	33.2	18.7	51.9	7.81	W., NE.	5.4
Winter	88	27.7	15.9	43.6	8.64	NW.	7.8
Year	80	134.6	94.6	229.2	29.40	NW., NE.	6.0

OTTAWA. The preceding chart, representing the climate of the city of Ottawa, Canada, is here introduced for convenience of reference. With one exception the data of this chart are identical in kind with those standing in corresponding columns of the large U. S. Signal Service charts published in the HANDBOOK; consequently a detailed explanation of its figures and suggestions as to the method of using the chart will be found in the article

entitled Climate (vol. ii., pages 185 to 191). The exception just alluded to concerns only the data standing in columns A and AA. The hours of the tri-daily observations of temperature are not identical with those given in the U. S. Signal Service charts. For the careful preparation of this chart I am indebted to the Hon. Charles Carpmael, Superintendent of the Canadian Meteorological Service, and also to the Hon. H. Beaumont Small, of Ottawa, who assisted me in so obtaining it.

Huntington Richards.

OVARIES, DISEASES AND NEW GROWTHS OF THE. It is impossible for anyone to appreciate the nature and extent of morbid changes within the ovary, unless he has familiarized himself with the normal variations in its physiological anatomy. These variations are so great, the structure and functions of the organ are so complex, that it becomes of vital importance for the surgeon to be provided with positive criteria of its health and disease, since upon his hasty decision at the operating-table often hangs the question of its removal. During the period of sexual activity the exterior of the organ presents a generally smooth, pearly, glistening appearance, relieved by occasional vesicular projections, which represent matured Graafian follicles, or by brownish spots and whitish depressions or cicatrices, the sites of ruptured ovisacs. It is important to note that, when congested (as during menstruation) an ovary may increase in size, assume a more spherical shape, and a pinkish or bluish hue, while the senile gland is small, irregular, of a dead white color, and frequently of a semi-cartilaginous consistence. These facts should be borne in mind in connection with the diagnosis of acute or chronic ovaritis.

Theoretically, it is difficult to find an ideal ovary, or one in which a careful microscopical search does not reveal evidences of circumscribed disease. Practically, however, we may be content to assume that an organ is normal which discharges its functions normally and shows no morbid changes sufficient to impair its general integrity. It is important to become thoroughly acquainted with the appearance of the normal ovisac, in order to form an intelligent idea as to the presence of diseased conditions. It is by no means easy to decide how large a Graafian body may become within normal limits, or what amount of fluid may collect within it before the diagnosis "hydrops folliculi" becomes justifiable. The presence of several vesicles as large as peas on the surface, or within the substance, of an ovary does not warrant us in asserting the existence of functional impairment, until we have carefully examined the stroma for other evidences of disease.

Is it possible to distinguish the normal ovary by the vaginal touch? Opinions differ on this point. In thin subjects a practised hand may, indeed, be able to detect the organ by the bimanual, or, better still, by the rectal or vesical touch; but the writer has no hesitation in affirming that it is only under exceptional circumstances that this can be accomplished. Schultze directs that the patient be placed upon her back, with the thighs flexed and rotated outward, so as to render the psoas muscles tense; the inner edges of the latter form guides to the ovaries, which lie at points equally distant from the muscles, Fallopian tubes, and cornua of the uterus. The organs may also be displaced downward by making traction on the uterus with a volsella, and are then accessible through the anterior rectal wall. The information gained is, of course, negative; we have not yet acquired sufficient diagnostic skill to recognize slight variations in the size of an ovary which still retains its position at the level of the pelvic brim.

The symptomatology of ovarian disease is by no means clearly defined, as will be inferred by a review of the following paragraphs on that topic. Just as we have every reason to anticipate many new discoveries in the field of ovarian pathology, so there is no doubt that we may yet ascertain the true origin of symptoms now referred to disease of the ovaries.

The element of *pain* in connection with affections of the pelvic organs is one on which great stress is laid, yet it is not uncommon to find that the peculiar pain described in the text-books as distinctly "ovarian" may co-exist with perfectly healthy organs—in short, that it may be due to disease of the tubes, or to the presence of peritonitic adhesions. Even "ovarian dysmenorrhœa," so clearly defined in many treatises on gynæcology, is coming to be regarded by thoughtful men as more or less a confession of ignorance, since it is a matter of daily experience that pain recurring at every monthly period may be due to several causes, some of which are still problematical. I believe that in the almost unexplored field of functional nervous diseases lies the solution of many problems in gynæcology which have so long vexed the minds of the inquiring.

The various symptoms usually referred to disease of the ovaries will be described and commented upon in their proper place. I only desire, in these introductory words, to guard the reader against the disappointment which he may feel at the brevity and apparent vagueness of the sections devoted to symptomatology. A writer on general medicine would be severely criticised if he described a set of symptoms as *possibly* belonging to a certain disease. Why, then, should not a gynæcologist, who draws largely upon his imagination, be held equally accountable?

In view of the present domination of the operative tendency in gynæcology, it may seem necessary to offer an excuse for dwelling upon the palliative treatment of ovarian disease. The topic is not a popular one, but, as this article is written for general practitioners, I cannot resist the temptation to remind the reader that such treatment is not entirely hopeless, and that the diseased ovaries are not necessarily shrouded in a mystery which only the laparotomist can penetrate. The surgical side of the question is not the only one, and there is hope for the patient in the office, as well as on the operating-table. But this question, also, is in a transition stage, and until it is settled a middle course is the safest.

I. Affections of the Ovary not Resulting in the Formation of Tumors.—1. *Malformations.*—Abnormalities in the development of the ovaries are seldom recognized during life. There may be a complete absence of one or both organs, or, more commonly, they may be present in a rudimentary condition. Rarely, a third ovary may exist.

Etiology.—Congenital absence of both ovaries nearly always co-exists with absence or arrested development of the pelvic organs. One ovary may be absent without the existence of any abnormality in the uterus, but, as a rule, the corresponding half of the latter organ is rudimentary, or the tube is defective in its outer portion. Arrested development of both ovaries is the most common of these conditions, and is generally, though not always, associated with pelvic organs of an infantile type and with retarded puberty. The individual has never progressed beyond the state of childhood. The primary cause of this phenomenon is unknown. It does not appear to be due either to heredity or to the general health of the woman, which is usually excellent. The influences which govern the development of the embryo are too subtle to allow of theorizing on the subject. Tait calls attention to a class of cases in which the growth of the ovaries is stunted as the result of zymotic diseases during childhood, especially of scarlet fever. The pelvic organs retain their infantile type, as in cases of congenital arrest of development. Arrest at a later period is probably the result of ovarian disease, and will be considered elsewhere. The presence of an accessory ovary has been explained in different ways; by some the extra organ is considered as a cotyledon or outgrowth from the original ovary, while others regard it as the result of a pathological process. Peritonitis in the fœtus (usually of syphilitic origin) leads to the formation of bands which separate, and eventually cause complete detachment of, certain portions of the gland.

Gross Anatomy.—A rudimentary ovary either preserves the elongated shape of the fœtal organ, or resembles the adult gland, but is small and shrunken. It is important to distinguish such an ovary from one that has become

atrophied physiologically, or as the result of disease. I have found ovaries buried in old adhesions, and so shrunken that it was almost impossible to identify them. The rudimentary condition of the other pelvic organs will serve to confirm the diagnosis. A few well authenticated cases are on record in which a third ovary existed; in one instance, Simély found no less than half a dozen small pedunculated bodies growing from the ovary of an infant, only one of which, however, presented the normal structure of the gland.

Minute Anatomy.—The histology of a rudimentary ovary points clearly to an arrest of development, as shown by the absence or imperfect character of the Graafian vesicles. Klebs has called attention to the fact that in certain cases in which ingrowths of germinal epithelium have been isolated in the midst of the stroma, without the formation of vesicles and ova, the histological structure resembles that of the testicle, so that if portions of the ovary became separated from the rest of the organ (as by long-continued constriction by bands of adhesions), doubt might arise as to whether the subject was or was not an hermaphrodite. It is easy to see how much importance might attach to this question in a medico-legal light.

Clinical History.—A woman whose ovaries are entirely absent is essentially a child. Aside from the imperfect condition of her sexual organs, she will present a physical and mental development corresponding to that age. This is not invariably the case, as I have seen a woman whose internal genitals were entirely wanting, yet the pudenda were of normal appearance, and the patient did not differ greatly from others of her age and condition. Sexual feeling is, of course, absent, or nearly so, menstruation does not appear, and the growth is stunted. In some instances the subject presents some of the characteristics of the male type—masculine tone of voice, absence of the feminine contour, growth of hair on the chin and upper lip, etc. Women with rudimentary ovaries may be assigned to two classes—those who do not menstruate at all, and those in whom the function is developed only to be arrested after a few years, or to be exercised at infrequent intervals. The history of the former is almost identical with that of the patients in whom the glands are entirely wanting, except that the infantile type is almost invariable. Epileptic attacks are common in such unfortunates. More commonly we meet with the following history: Puberty is delayed (to the sixteenth or eighteenth year), its approach being heralded by pelvic pains which seem to indicate an effort on the part of nature to establish the function. After a few months these may cease entirely, and no indications may exist of the returning periods; or a scanty flow may appear at irregular intervals, and then cease entirely. Other women may menstruate with some regularity for three or four years, although the amount is scanty, and then cease. The physical development of such subjects is imperfect, while sexual feeling is nearly always wanting.

In Mr. Tait's opinion, the largest class of patients whose ovaries may fairly be regarded as non-developed consists of women whose general physical condition is good, but whose menstruation is delayed, and then appears with fair regularity for eight or ten years, the flow being normal in quantity but accompanied by pain. Not only is the menopause premature in these cases, but some slight cause (a chronic disease, mental anxiety, etc.) which would not affect the function in other women, may arrest it temporarily or completely. In other words, many ovaries, although not strictly rudimentary, may never become sufficiently developed to maintain their activity during the ordinary period of sexual life, especially if the stimulus of marriage is wanting. Such patients as those last described do not, of course, present the same general evidences of arrested development as do those who have never menstruated, and the results of treatment are widely different. The symptom of amenorrhœa being the most important one, it is evident that much care must be exercised in discriminating between amenorrhœa due to non-development, and that arising from general or local disease.

Diagnosis.—Having obtained such a history as the one above described, we should note the general appearance of the patient, remembering that anæmia is a common cause of amenorrhœa. The evidence afforded by a digital examination is mainly negative; while the existence of an infantile condition of the vagina and uterus, or an entire absence of these organs, will readily be recognized, little information will be gained regarding the ovaries, even though the patient is examined per rectum and under anæsthesia. The absence of tenderness on palpation, or of any appreciable enlargement of the glands, may justify the inference that the menstrual irregularities are due to imperfect development rather than to disease.

We have no certain means of ascertaining during life the presence of accessory ovaries, or the absence of one organ; the persistence of menstruation after the removal of both ovaries is no longer regarded as an evidence that a third exists. We decide that rudimentary ovaries are not functionally useless, not only from the fact that menstruation persists, but from the *tout ensemble* of the individual, and the degree of development of the uterus, a question to be established by a careful bimanual examination and measurements with the sound. The evidences of some disease which might retard menstruation should be sought for.

Prognosis.—It is evident that encouragement can only be offered to such patients as have shown some manifestations of sexual activity, *i.e.*, to those in whom the other pelvic organs are not rudimentary.

Treatment.—This has for its object the stimulation of the pelvic circulation and with it the awakening of the dormant activity of the ovaries; it will be successful according to the extent to which nature has already succeeded in establishing the menstrual function. An attempt should be made to build up the general condition, if it is poor, by the use of tonics, especially iron, massage, electricity, and a careful attention to diet. Aside from the drugs which are usually administered for the purpose of determining an increased flow of blood to the pelvic vessels (iron and aloes pill, apiol, binoxide of manganese), hot hip-baths, and vaginal douches at the time of the expected period, applications to the uterine cavity, the introduction of tents, the sound, etc., have been recommended.

Electricity is doubtless the most valuable agent which we possess. A large flat sponge connected with one pole of a faradic battery should be placed over the sacrum, while the other pole is applied alternately over either ovary, a current of moderate strength being used. This should be repeated two or three times weekly, the treatment being continued for months if necessary. A still better way is to introduce a rheophore into the uterine cavity, while the other pole is placed over the fundus and the ovary. If the faradic current produces no result, galvanism may be tried. The so-called "galvanic stem-pessary" has been much lauded in connection with the treatment of amenorrhœa of ovarian origin, but it is by no means certain that this instrument accomplishes anything more than an irritation or stimulation of the uterus; the existence of any distinct galvanic action is doubtful. The same objections exist in the case of these stems as in that of other intra-uterine pessaries, and I cannot see any advantage which they possess over the rheophore. Marriage has been recommended as a means of developing immature ovaries and arousing proper sexual feeling; but this step should not be taken without a full understanding on the part of all parties that it is purely experimental. It is true that many women who menstruated imperfectly or not at all before marriage have apparently matured afterward, and have not only had a normal flow, but have become pregnant. But there are not a few instances in which neither the menstrual function nor sexual feeling is quickened, and disappointment and domestic unhappiness result.

2. *Displacements of the Ovary.*—(*a*) *Hernia.* Hernia of the ovary is generally a congenital displacement, the inguinal canal being the most common location. Kiwisch reports a rare case, in which the ovary was found in the obturator foramen, while Leopold removed an ovary and

the left cornu of the uterus which formed a hernial protrusion. An acquired hernia of the ovary may also be vaginal, crural, or even umbilical, and is usually associated with hernia of the omentum or intestine. A ventral hernia after laparotomy may contain the uterus and its appendages.

Etiology.—The congenital displacement of the ovaries into the inguinal canal, or even into the labia majora, is explained by reference to the descent of the testes—in fact, in many recorded cases of supposed hernia of the ovary the organs were really testicles, so that the question of hermaphroditism might readily arise. Acquired hernia can only occur when the attachments of the ovary are unusually long or relaxed; the tube is commonly displaced at the same time. The displacement may occur simultaneously with an inguinal hernia as the result of a strain or fall. Weinlechner (*Wiener med. Wochenschrift*, 1877) mentions an example. It is somewhat apt to occur during the general relaxation of the pelvic organs and of their attachments, after delivery. Tait has described cases of congenital absence of the broad ligaments; under these circumstances the range of mobility of the ovaries might be considerable.

Gross Anatomy.—When situated in the inguinal canal (the congenital variety is confined to this region) or labia majora, the ovaries appear as small tumors about the size of a pigeon's egg, and closely resembling testicles in shape and consistence. Sometimes they are readily reducible, but more often they are fixed by adhesions. Strangulation is not a rare accident. If intestine or omentum is present in the sac, the presence of the ovary may not be suspected. The coverings of the hernia are, of course, the same as those of the omental or intestinal variety. Englisch found the hernia double in one-third of the reported cases. The displaced ovary may undergo cystic or even carcinomatous degeneration, or it may become atrophied.

Minute Anatomy.—The identity of the ovary will be revealed by the microscope. The presence of Graafian vesicles and ova will clear up any doubt which may exist as to the true sex of the subject. It should be remembered that not only do these displaced ovaries bear a close resemblance to testicles macroscopically, but the minute anatomy of the former, if these are undeveloped, is quite similar to that of the male organ. That a hernial ovary may remain functionally perfect is proved histologically as well as physiologically.

Clinical History.—A patient with this displacement of the ovary will ordinarily state that she has long noticed a small lump in one or both groins or labia, which may remain stationary or disappear when she lies down. The swelling may not have attracted her attention until puberty, when she began to notice that just before the appearance of the menstrual flow it became enlarged and tender, returning to its previous condition after menstruation. Pressure on the tumor, she has noticed, causes a peculiar, sickening pain, or even nausea. Facts regarding the sexual feeling will mainly be negative. With this history we should be led to suspect the nature of the enlargement. The displaced ovary may become the seat of inflammation, or it may become incarcerated, when the symptoms will be more grave.

Diagnosis.—This will be based upon the location and character of the swelling, the manner in which it is affected by the menstrual nisus, its tenderness on palpation, and the reflex symptoms which may result from pressure upon it. Thus, nausea has frequently been noticed, and in one instance Routh ("Trans. Royal Med. and Chir. Soc.," *Lancet*, January 28, 1882) caused marked sexual excitement by pressing on the inguinal tumor. In examining a supposed hernia of the ovary we have not only to differentiate it from an ordinary hernia and from hydrocele of the round ligament, from parietal and peritoneal tumors, but to decide whether the hernia consists of the ovary alone (with the corresponding tube), or of the ovary plus intestine, omentum, or inflammatory adhesions. An ovary situated near the external ring, or in the labium, can nearly always be felt as a distinct circumscribed tumor, dull on percussion and without any impulse on coughing. If it is readily reducible, of course the diagnosis of hernia of the ovary is rendered highly probable. A careful bimanual examination of the uterus will sometimes throw light upon the question; if this organ be moved by means of the hand or a sound, traction will be made upon the hernia. The physician may be called upon to decide whether the hernial protrusion is an ovary or a testicle, *i.e.*, whether the subject is an hermaphrodite or not. The decision, as before stated, is sometimes difficult; if the pelvic organs are well developed, and if the menstrual disturbance is present, there can be no reasonable doubt as to the true sex.

As regards the various forms of acquired herniæ of the ovary, it must be acknowledged that the diagnosis is often doubtful, especially if the gland cannot be isolated. Acquired hernia is usually reducible, congenital hernia seldom; the ovary in the former case may, however, become incarcerated together with intestine or omentum. The periodical pain and enlargement of the imprisoned mass should lead one to think of the possibility of its containing an ovary. Vaginal hernia (*ovariocele vaginalis*) is really an exaggerated degree of prolapsus; in order that the gland may sink down behind the vagina and form a protrusion in the posterior wall of that canal, it is necessary that there should be a rupture or relaxation of the deep pelvic fascia. The diagnosis is not so easy as it may seem to be, especially if the enlargement appears near the vulva; it may be mistaken for a small scybalous mass, a cyst, abscess, or tumor of the vaginal wall.

Prognosis.—Congenital herniæ of the ovary, being situated in the inguinal canal or at its termination, and being irreducible, are subject to some of the same complications as the ordinary variety. As the gland is subject to periodical congestion, as well as to disease, the tendency to which is increased by its abnormal position, it can readily be understood that strangulation may occur and may lead to a fatal termination. Cystic degeneration may occur, and an ovarian cyst has been removed from the region of the external inguinal ring.

The prognosis in acquired hernia differs in different cases; the hernia is generally reducible, but inflammatory complications sometimes occur, leading to suppuration and peritonitis. If the ovary is adherent to a displaced organ it will share in the accidents to which that organ is liable. A vaginal hernia is exposed to frequent injury, so that the ovary is liable to become inflamed, especially if it is irreducible.

Treatment.—This may be described as palliative and radical or curative. If the hernia is reducible taxis should be employed, a suitable pad or truss being adjusted; it is hardly necessary to add that manipulation of a displaced ovary should be as gentle as possible. If taxis has been tried unsuccessfully, it is well to apply continued pressure (hydrostatic, or by sand-bags). If the ovary cannot be replaced, it must be protected by a concave pad or a truss, pain being relieved by the usual means. Local applications should be used with circumspection during the menstrual period, lest the physiological be converted into a pathological congestion.

In the operative treatment of this displacement the surgeon will be governed by two considerations, the relief of pain, and the saving of life. Even the most conservative will admit the wisdom of removing ovaries which are practically useless and are prone to become diseased, if they are not already so, especially as the operation is not as dangerous as laparotomy.

(*b*) *Prolapse of the Ovary.* Reference has been made, not only to the attachments of the ovary, but to its normal range of mobility, as determined by the distention of the bladder as well as by the enlargement of the uterus during pregnancy. The reader's attention is also called to the physiological variations in size and weight which the gland presents during the menstrual and puerperal periods. Bearing these facts in mind, he will readily see how a disturbance of the delicate adjustment of the organ, by an abnormal increase in its weight, a weakening or relaxation of its supports, or an unusual traction upon it, may cause it to change its position, and sink downward toward the pelvic floor. Prolapse arising from an en-

largement of the ovary is the result of causes to be studied subsequently in connection with diseases of the organ; unlike hernia, it is secondary to, or symptomatic of, some pathological condition of the pelvic organs.

Etiology.—An ovary may become prolapsed because its weight increases to such an extent as to overcome its natural supports; the ovarian ligament may be stretched during pregnancy and may fail to regain its former tone after parturition (the ovary increasing in size at the same time), or the organ may be drawn out of place by the adhesions resulting from localized peritonitis. Displacement from these causes is independent of changes in the position of the uterus. The ovarian attachments are frequently over-stretched by the weight of a retroverted or prolapsed uterus, while in complete inversion of that organ the ovaries may be dragged downward into the infundibulum. An intra-pelvic growth may displace an ovary, but it is a question if this is an example of true prolapse. Although prolapse is a frequent accompaniment of retroflexion, the ovaries are felt in Douglas's pouch in acquired anteflexion more frequently than is commonly supposed. In general, I have noticed that the ovaries are most often displaced in connection with flexions which are clearly caused, or aggravated, by peri-uterine inflammation, so that it would seem as if the traction of adhesions was an important factor in producing the displacement. In a small number of cases the condition may be regarded as congenital.

Anatomy.—In true or primary prolapse (called by Olshausen, *descensus ovariorum*) the ovary sinks below its normal plane, while the uterus remains in position. In lesser degrees of dislocation the organ may be only slightly, if at all, enlarged, while the infundibulo-pelvic ligament is longer than usual; in more marked cases the ovary will be found behind the uterus, lying just above the level of the sacro-uterine ligaments in that portion of the posterior fossa which Polk has called the "retro-ovarian shelf." In extreme dislocation it will lie at the bottom of Douglas's pouch. I have rarely, if ever, found the ovaries exactly in the lateral pouches unless they were fixed there by adhesions. The left ovary is more commonly prolapsed, not only because it is more subject to disease, but by reason of its greater enlargement during pregnancy. Several influences tend to produce this condition, chief among which is the valveless state of the left spermatic vein, whereby that vessel is affected by an obstruction in the general circulation. The conformation of Douglas's pouch allows the left ovary to sink to a lower level than the right, and hence to be more accessible to the examining finger. This may account to some extent for the comparative frequency with which prolapse is detected on that side. Simultaneous primary dislocation of both ovaries is not common. The ovary is rarely found in front of the uterus or between the uterus and the bladder; this displacement is nearly always the result of a former peritonitis. As regards the condition of the displaced organ, it may be said, broadly, that it is usually the seat of disease, but it is not always easy to affirm whether the disease existed *before* the prolapse, or was caused by the continued congestion resulting from obstruction of the ovarian vessels; it is generally safe to assume that disease originally existed and that it was aggravated by the abnormal position.

Subinvolution of the uterus is a frequent cause of retroversion; as the heavy organ inclines backward, decided traction is exercised upon the infundibulo-pelvic ligaments, the ovaries being drawn backwards and downwards, so that they lie near the uterus and somewhat in front of it. Quite different is the condition if the ovaries are fixed (together with the uterus), by adhesions which compress their vessels, hinder their periodical enlargement, and imprison the organs at the bottom of Douglas's pouch against the rectum, where they are constantly subject to disturbing influences (defecation, coition, etc.); they will then invariably be found to be diseased, and the disease may fairly be regarded in this instance as secondary to the displacement. A curious condition sometimes encountered at the examining-table (less often by the pathologist) is imprisonment of an otherwise movable ovary beneath the fundus of a retroflexed uterus; if the latter can be raised the ovary may be liberated.

Dislocation of one or both ovaries as the result of peritonitis, or associated with disease of the tubes, is frequently observed at autopsies; the pathological conditions are often so complicated that it is impossible to trace the sequence. The uterus may or may not be displaced. It is a question how far many of these displaced ovaries can be regarded as prolapsed, since it is impossible to say whether they originally sank below their normal plane as the result of enlargement due to disease, or were drawn downward by peritonitic adhesions.

Clinical History.—Since prolapse is a consequence of disease, and not a disease itself, many of the symptoms are those of chronic ovaritis and will be described in detail subsequently. The subjective symptoms referred to the mechanical condition will readily be understood on recalling the relations of an ovary when lying in Douglas's pouch. From its close proximity to the rectum, it is liable to be affected by the passage of faeces, especially when constipation exists, as it usually does in women. The patient will complain of darting, sickening pains during defecation, which may persist long after the bowel has been emptied. Nausea, or even sexual excitement, may be caused by the presence of hardened fecal masses. The unfortunate patient looks forward with dread to every movement of the bowels, and feels completely exhausted for hours afterward. Reflex disturbances (especially frequent micturition, vesical and rectal tenesmus) are often present. Exposed as the sensitive organ is to injury from the side of the vagina, dyspareunia—painful coition—is a common symptom. Locomotion is attended with sickening pain in the sacrum and inguinal region, especially the left, the pain shooting down the thigh along the genito-crural nerve. General reflex neuralgiæ are often noticed, the breast being a common seat of this distressing complication. In my experience mammary neuralgia is usually confined to the side on which is the affected ovary. Dysmenorrhœa, as may be inferred, is more or less marked. As a result of her sufferings the mind of the unhappy woman may be affected and suicidal tendencies are sometimes noted. This brief picture represents the main symptoms of a well-marked case of prolapsed and diseased ovary; the reader must not suppose that these are invariably present. I have seen many cases in which the condition would not have been suspected from the subjective history. It is the enlarged tender organ, fixed by adhesions above the vaginal fornix, that occasions such distressing phenomena; the small movable ovaries which follow a retroverted uterus in its ascent and descent are not so likely to give trouble, unless one of them happens to be caught between the fundus and the sacrum, as Goodell suggests. I cannot believe that this is a very frequent accident. It is not always easy to differentiate the uterine from the ovarian symptoms, such as menorrhagia, which might be ascribed to chronic inflammation of either organ.

Diagnosis.—This is seldom difficult. It involves the practice of the most elementary principles of gynæcological examination. With the exercise of ordinary care every physician ought to be able to detect a prolapsed ovary, even if he has never felt one before. With the patient on the back, the examining finger is introduced into the vagina and determines first the position of the uterus—whether the fundus is anterior or posterior; in the former case the finger-tip is slipped backward over the cervix into the posterior fornix, where a body will be felt, generally on the left side, varying in size from an almond to an English walnut. It may slip away from the finger, or remain fixed; pressure upon it produces a peculiar, sickening pain, which may be intense and attended with the phenomena above described. If the uterus is retroverted or retroflexed, the ovary will be felt below, or a little to one side of it. If the posterior fornix is deep, or the ovary small and not completely prolapsed, it may be overlooked, even by an expert, especially if the patient is examined only upon the back. It is a good routine practice to explore the posterior cul-de-sac while the woman is in the left lateral post-

ure, as the perineum can be pushed upward at least half an inch, so that the finger reaches that additional distance along the posterior vaginal wall.

A prolapsed ovary may be mistaken for a mass of hardened fæces, an inflammatory exudation, the fundus of a retroflexed uterus, or a small subperitoneal fibroid, and *vice versa*. Scybala, high up in the rectum, may closely simulate ovaries, and I do not regard the error as entirely inexcusable; it will be noticed that the former lie behind the uterus rather than to one side of it, and that if one of them is imprisoned between the finger-tip and the sacrum, it is soft and compressible, while an ovary either slips away, or pressure upon it causes the characteristic "ovarian" pain. But some displaced ovaries are remarkably insensitive, while nervous patients may complain of severe pain when the rectal wall is touched. A small pelvic abscess, or the remains of a former inflammation, may resemble an ovary. Palpation may cause pain, but it is rather of a sore, aching character; the enlargement is more diffuse than that of a prolapsed ovary, and the patient allows firmer pressure to be made upon it without flinching. The fundus of a retroflexed uterus is directly continuous with the cervix; the cautious use of the probe (*not the sound* at the first examination) will throw light upon the question. By placing the patient upon the hands and knees, or even in Sims's posture, the uterus may be replaced, when the tumor will disappear. A pedunculated subperitoneal fibroid must be distinguished from an ovary by its greater hardness and the absence of pain on pressure; when the fibroid growth is surrounded by recent peritonitic adhesions a differential diagnosis from the examination alone may be impossible. Several complicated conditions might be mentioned in which a positive opinion is withheld by the most experienced. Cystic degeneration of the displaced ovary, accompanying enlargement of the tube, etc., may complicate simple prolapse. The question of the diagnosis of salpingitis has been discussed elsewhere (vol. iii.), but I would simply add, in passing, that the daily experience of both the laparotomist and the pathologist proves that a small tumor behind, and a little to one side of, the uterus may be an enlarged ovary, or tube, or both, or—neither. The reader should bear in mind the possibility of anterior dislocation of the ovary, when the organ will be felt through the anterior fornix.

Prognosis.—As regards the displacement, simply as a displacement, the prognosis concerns the possibility of reposition of the ovary to its normal plane and its maintenance there. If the uterus is retroverted at the same time, and can be replaced, the prognosis for an ultimate cure is good; under any other circumstances I have no hesitation in saying that, in spite of the vast amount that has been written on this subject, gynæcologists have not met with very flattering success in their attempts at curative treatment. A patient with a prolapsed, tender, immovable ovary offers a discouraging prospect to a specialist whose tendencies are not especially surgical. We may assure such a patient that with strict attention to hygienic measures, as well as with local treatment, she may improve in the course of a few months so that her life will become more bearable; but it would be either foolish or dishonest to promise her that her ovaries could ever be completely replaced. When the additional element of tubal disease is introduced, the prognosis becomes still more gloomy, because now the woman's life, in addition to her comfort, is in danger.

Treatment.—This is essentially local, and, unfortunately, the results are not particularly brilliant. If oöphoritis is present, that condition should receive due attention; a diseased ovary, when resting in Douglas's pouch, is, of course, more accessible to treatment than when it is higher up in the pelvis. Disturbing elements are to be eliminated as far as possible; the bowels must be moved daily by mild laxatives or enemata, the general health must be improved, and physiological rest must be maintained, especially at the menstrual periods. Sexual intercourse, if permitted at all, must be duly regulated; when the act is attended by severe pain and an increase in the local tenderness, the physician will do well to see the patient's husband and to explain to him that without his co-operation treatment is almost useless. The bromides sometimes appear to exercise a happy sedative effect, while ergotin tends to relieve congestion if administered before and during the periods; Tait recommends highly a combination of the latter with the bromide and chlorate of potash, while Goodell administers one-twenty-fourth of a grain of corrosive sublimate with five grains of chloride of ammonium thrice daily.

As regards the local treatment, it may be stated briefly, that if a prolapsed ovary is movable it should be lifted out of harm's way by means of an appropriate pessary; if it is fixed, a fair trial should be made of palliative measures, such as hot vaginal injections, applications of iodine, galvanism, and the introduction of glycerin-tampons, before the last resort is tried—laparotomy. When the uterus is retroverted, the replacement of the organ is often sufficient, without any special appliance for keeping the ovaries in position; it is generally advisable to throw the fundus well forward, and to this end a sharp curve is given to the upper portion of the pessary, or the posterior cross-bar is made broad and thick (bulb-pessary), so as to distend the posterior fornix to its greatest extent, and thus to elevate the displaced organs. Unfortunately, the latter are often so sensitive that they will not tolerate the pressure of the cross-bar; the gynæcologist is driven to his wit's end in such cases to devise some means of keeping up the ovaries without exercising direct pressure upon them. The rectum and sacral nerves may also resent continued pressure. The cross-bar, or the entire instrument, may be made of soft rubber, or an air-cushion or Gariel pessary may be introduced with advantage; we thus lessen the pressure, but at the expense of the actual supporting-power, since soft-rubber pessaries soon lose their shape. Sometimes a hard-rubber instrument may be moulded in such a way that there is an indentation at the point where it is liable to press upon the ovary. By this simple expedient a patient is enabled to wear an ordinary bulb-pessary, after she has tried every variety of supporter in vain, while the attendant who succeeds in overcoming the difficulty will receive no little credit. In some cases it is impossible to keep the ovaries elevated, even when the uterus is in position. They descend behind the cross-bar and are nipped between it and the rectum. The remedy is sometimes so much worse than the disease that patients prefer to endure the distress occasioned by retroflexion and prolapsed ovaries rather than wear an instrument. Dr. Campbell's method of pneumatic reposition of the displaced organs, by placing the patient in the knee-chest position and opening the vagina to allow the air to distend it, may be applied with advantage to cases in which the ovaries are freely movable. By repeating this manœuvre, at least twice daily, the strain upon the relaxed ligaments and vessels is relieved, so that the latter tend to recover their tone, while the patient experiences a decided amelioration of her symptoms. A firm tamponade is another temporary expedient for elevating prolapsed ovaries, in the hope that they may eventually remain out of harm's way; the advantages of the cotton tampon is that it accomplishes the same result as a pessary without exerting the same painful pressure. Bozeman's method of packing, or "columning," the vagina, with the patient in the knee-chest position, offers superior advantages, since it includes the two elements—pneumatic reposition and firm, continued pressure.

The Weir Mitchell rest-cure is another indirect method of treatment in these cases, for the details of which the reader is referred to that author's works. In a certain proportion of cases of prolapsed ovaries the question of operative treatment will naturally arise. The reader will be governed by the urgency of the symptoms, the solicitations of the patient, and by his own conscience. Remembering that a *movable* prolapsed ovary is always susceptible to palliative treatment, the general practitioner (who will generally be found on the side of conservatism) will be slow to recommend a radical operation; when the organ is *fixed*, it is another matter, as we shall see. An in-

genious operation has been devised, and successfully performed, by Dr. Imlach, of Liverpool; it is, in effect, a bold application of the process of shortening the round ligaments for the cure of uterine displacement. Oöphorrhaphy, as it is termed, consists in opening the abdomen, shortening the relaxed infundibulo-pelvic ligament, and suturing it anew to the hilum of the prolapsed ovary, which is thus maintained in its normal position. While the displacement is thus corrected, no guarantee is offered that the organ will remain permanently elevated, nor is there reason to believe that it will be cured if actually diseased. Few operators at the present day would possess sufficient self-restraint to stop short of actual extirpation.

When an ovary has become fixed in an abnormal position as the result of peritonitis, the prospects of success from palliative treatment are not very encouraging. The gynæcologist whose tendencies are non-surgical must acknowledge that his resources are as crude as they are limited. Two indications are clearly present—to raise the prolapsed organ and to diminish its tenderness. The first will be accomplished (if it can be accomplished at all) by a persistent, systematic use of the tampon, the latter by hot vaginal injections, local applications to the fornix, and cotton soaked in some emollient. Electricity, it should be emphasized, is a valuable adjuvant; local massage is, from the nature of the case, practically out of the question. The following brief outline of the *palliative* treatment in a supposed case of prolapsed ovary which is adherent at the bottom of Douglas's pouch, is suggested for the benefit of the general practitioner. Explain the patient's exact condition to her at the outset, giving an extremely guarded prognosis, and causing her to understand that her treatment is to be an affair of months, not of weeks. In order to fortify yourself, it may be well to state to her frankly that she might consult many of your colleagues who would advise an immediate operation, but that you wish to make a fair trial of less heroic means first. Do not promise a *cure*, but a probable relief of the distressing symptoms. If the woman will not consent to receive treatment at least twice a week, it will not benefit materially either the patient or your own reputation; if conservative gynæcology is to hold its own at all against operative, it must have a fair trial. Having given due attention to the patient's general condition as regards the treatment of anæmia, gastric troubles, constipation, etc., the correction of bad habits (especially the habitual use of stimulants and narcotics), caution her against such things as might aggravate her local trouble, chief among which are immoderate indulgence in sexual intercourse and over-exertion, especially at the monthly period. Insist upon the employment of a copious hot vaginal douche twice daily, observing all the details upon the importance of which Dr. Emmet lays so much stress. Supposing the patient to visit your office twice a week, paint her posterior vaginal fornix with tincture of iodine or equal parts of the latter and tincture of aconite root, and then apply a tampon of absorbent cotton soaked in pure glycerin, tincture of iodine, tannin, chloral and glycerin (gr. xx. to ʒ j.), or boro-glyceride, after which pack the vagina with balls of cotton, so disposed that they fill the posterior pouch and exert firm, even, and continuous pressure upon the prolapsed ovary. By placing the patient in the knee-chest position, not only is the vagina thoroughly distended so that each tampon may be placed exactly in its proper place, but the physician can work without the aid of a nurse. Once a week, or twice, if possible, pass a mild galvanic current (best measured by a galvanometer) through the affected ovary, the negative pole being a flat sponge placed over the corresponding inguinal region—the positive, a ball-electrode inserted into the posterior fornix (at the site of the prolapsed organ); begin with a séance of ten or fifteen minutes and prolong it gradually to half an hour. A blister applied over the ovarian regions at intervals of two or three weeks may be of some benefit. If the local tenderness is sufficiently lessened to allow it, before making the application to the vault, insert one or two fingers and make steady pressure upon the prolapsed organ, with the view of raising it towards its normal plane. Since there may be an undetected pyosalpinx attached to the ovary, this manipulation is not to be generally recommended. You have now begun a line of treatment which aims to meet the indications simply and rationally. Encourage the patient to persist with it for at least six months before entertaining seriously the question of laparotomy. Unsatisfactory as this treatment may appear, it is not by any means to be despised. Every gynæcologist has met with cases in which an enlarged and prolapsed organ, tender as the ball of the eye, lying immovable at the bottom of Douglas's pouch, the seat of intolerable neuralgia, has been sensibly diminished in size, and has been elevated in the pelvis until it could barely be felt by the examining finger, while the woman, before an invalid, was able to walk about comfortably—all this as the result of patient routine treatment. Doubtless this measure of success is the exception, but it is well to rid ourselves of the idea that for prolapse of the ovary with fixation there is no possible relief except in extirpation of the offending organ. As to the indications for this *dernier ressort*, these will be considered more properly under the treatment of oöphoritis, although they have essentially been described already. It may be added, in this connection, that vaginal oöphorectomy was formerly considered as specially applicable to this class of cases; but the results have not justified the hopes of its originators. To remove an ovary through a small incision in the fornix the operator must work in the dark; he cannot be sure that his pedicle has been properly secured, and the drainage is often defective.

3. *Functional Affections of the Ovary; Ovarian Neuralgia.*—By reason of the inherent difficulties of the subject, this chapter of ovarian pathology is necessarily brief and unsatisfactory. Some authorities deny the existence of a purely functional nervous affection of the ovary, referring all the local and reflex neuralgiæ in this region to actual disease of the organ, while others go to the other extreme and make the diagnosis "ovaralgia" an excuse for non-interference in cases in which an operation is clearly indicated. In the lack of positive evidence, a middle course should be adopted. It is to be hoped that the solution of the problem will not be left entirely to gynæcologists, since neurologists might throw much light upon it if they bestowed on it the study which its importance warrants. Whether the neuralgic pains referred to diseased glands and to those which present no morbid appearances are the same in character or not, whether they are to be referred primarily to an irritation of the intra-ovarian nerve-filaments, or to the compression of larger branches by the adhesions resulting from former peri-oöphoritis, it is, of course, impossible to affirm, without indulging in pure speculation. There are unquestionably forms of pelvic nerve-pain which are mistaken for ovaralgia; with greater refinement in diagnosis we shall, doubtless, be able to discriminate between the cases which will be benefited by laparotomy and those in which it is hopeless to expect a cure by extirpation of the appendages. No reference is made to the existence of actual disease in this connection.

Assuming, then, after this long preamble, that ovarian neuralgia is a neuralgia referred to the nerve-plexuses in or near the ovary, we shall regard it here, *not* as symptomatic of oöphoritis or peri-oöphoritis, but as an affection *per se*, and as such deserving special treatment.

Etiology.—Oöphoralgia is a frequent accompaniment of hysteria, when it is often associated with other visceral neuroses—intercostal neuralgia, headache, etc. But it may also be the expression of a general neuralgic condition, as in the case of a patient whose nerve-pains are intimately related to changes in the weather; sometimes these take the form of facial or occipital neuralgia, sometimes of brachial or crural, while occasionally the pain is referred to the ovarian region. Pain in the region of the ovary may be entirely of a reflex character, referable to some affection of the uterus, such as laceration or malignant disease of the cervix. From the preliminary remarks on the anatomical relations of the ovary, it will be inferred that its nerves are liable to be directly

affected by displacement or disease in neighboring organs; this is borne out practically by the fact that the *left* ovary is most frequently the seat of pain. The periodical congestion of the glands at the monthly periods is an important etiological factor, producing, as it does, symptoms which have been described, rightly or wrongly, as constituting "neuralgic dysmenorrhœa." Priestley's "intermenstrual dysmenorrhœa" may be another expression of the same ovarian pain. To summarize—oöphoralgia may be due to local, general, or reflex causes.

Anatomy.—Theoretically, in pure ovaralgia the ovary should be nearly, or quite normal, but until we can define strictly the extent to which the structure of the organ can vary from the type described in the books without being regarded as the seat of disease, we must use this term with caution. Circumscribed indurations of the cortex or stroma, insignificant as they may appear anatomically, may, by reason of pressure on included nerve-filaments, occasion an amount of pain entirely out of proportion to the actual disease.

Clinical History.—It is unnecessary to describe the protean collection of symptoms included under the name hysteria, since we are concerned with only one of them. The patient will complain of a darting or boring pain, generally in the left groin, sometimes in both; it is more apt to be confined to the abdomen; pain in the hip and sacrum being significant rather of prolapsed ovary. The corresponding crural nerve may be affected, and not seldom mastodynia is present also. The suddenness of its onset, its agonizing character and intermittency, as well as the simultaneous occurrence of other neuralgiæ, will lead the physician to think that he has probably to do with a purely neurotic affection. If, in addition, hysterical manifestations (hemi-anæsthesia or hyperæsthesia of the corresponding side) are present, which are aggravated by deep pressure over the ovarian region, the suspicion will be confirmed—in the absence of positive evidences of disease on local examination.

Diagnosis.—This turns entirely upon the result of the physical examination; hence it is unnecessary to say that this should be *thorough*, since it may involve the performance of a grave operation. Do not be satisfied with a hasty bimanual examination, but look the patient over from head to foot. The most eminent consultant in general medicine would not stake his reputation on a diagnosis in an obscure case until he had interrogated every organ in the body—is the gynæcologist less fallible, or is his art so much simpler, that he can decide the most weighty questions without a moment's hesitation and merely by the introduction of his finger? Examine the pelvis carefully and systematically, noting the presence of abnormalities, not only in the genital tract but in the urinary system and rectum, employing anæsthesia if necessary. Note carefully the effect of deep pressure in the inguinal region to which the pain is referred. Olshausen's hint regarding differential diagnosis is a useful one in hysterical cases, viz., that pressure upon a tender, diseased ovary causes a woman to wince and to give a cry of pain, while palpation over an organ which is simply irritable occasions strong contraction of the abdominal muscles, with general symptoms, or even convulsions. In cases of pure oöphoralgia not attendant upon hysteria, deep pressure may be borne without increase of the local pain. The vaginal fornix having been carefully explored with the view of detecting a prolapsed ovary, the attendant may think that his task is at an end. But the importance of the case demands further search. Anæsthetize the patient and repeat the examination, for an ovary may be considerably enlarged and yet it may not be felt through the vagina. In a thin subject, whose abdominal walls are thoroughly relaxed by an anæsthetic, any marked abnormality will be detected. If necessary, the rectal, or even the vesical, touch may be employed, with or without simultaneous traction on the uterus. During this thorough exploration of the pelvis other obscure causes of nerve-pain will be eliminated; among these may be mentioned indurations in the broad or utero-sacral ligaments, small pelvic abscesses, tumors, disease of the pelvic bones, etc. The detection of actual inflammation of the pelvic nerves or vessels lies, of course, beyond the scope of the bimanual touch.

Comparing the patient's history (especially as to the absence of former ovarian disease or pelvic peritonitis) and subjective symptoms with the negative results of the physical examination, the physician is warranted in assuming that she is the subject of ovarian neuralgia, with the reservation that this may be merely symptomatic of some organic trouble that has escaped his *tactus eruditus*.

Prognosis.—This is doubtful, since there is always a certain amount of uncertainty with regard to the cause of the pain. If not a symptom of organic disease within the pelvis, oöphoralgia may disappear as suddenly as it came, only to return at rare intervals. Sometimes it seems to be subject to the same conditions as other neuralgiæ—changes of the weather, general impairment of nutrition, etc. If the patient is a subject of neuralgia (hereditary or acquired), the prognosis is less favorable. As a symptom of hysteria, ovarian irritation is not usually permanent, but may come and go like the other phenomena peculiar to the condition. Recurring dysmenorrhœa of an ovarian type, especially if it increases in severity, should awaken the suspicion of organic disease, and render the prognosis less favorable.

Treatment.—The treatment of hysteria would be out of place here. As regards the alleviation of the pain in the ovarian region, it may be said that the internal medication is the same as in ordinary neuralgia, while the local treatment is that suitable to disease of the pelvic organs, the main object of which is to allay or prevent excessive congestion. Hot vaginal douches may give some relief, while blisters, cups, etc., are not to be despised. As the affected ovary (or its environs) is not accessible to treatment from the side of the vagina, the surface of the abdomen immediately over the tender spot must be utilized. The most valuable agent is electricity. Place a large, flat sponge, connected with the negative pole, over the sacrum and a sponge-electrode over the ovarian region, and pass a moderate constant current for from fifteen to thirty minutes, gradually increasing its strength according as the patient can tolerate it. The object is not to *cause* pain but to *relieve* it; hence the necessity of discrimination in the use of this agent. The dosage should be regulated by a galvanometer. The séance should be repeated at intervals of two or three days, and the treatment should be continued for months, if need be, before the attendant ventures to suggest laparotomy.

Removal of the normal or slightly diseased ovaries for the relief of *pain* alone—excluding all other indications for oöphorectomy—is, in most instances, a purely experimental operation, and should be distinctly regarded as such. It will be evident to anyone who takes the trouble to keep under observation for a few years a number of women whose ovaries have been removed for the relief of constant pain, aggravated at the time of the menstrual flow, that a certain proportion of them will not fail to bear sad testimony to the fact that, although they do not menstruate any longer, the old pain persists.

4. *Inflammation of the Ovary.*—Under this head may be included hyperæmia, and acute and chronic oöphoritis.

(*a*) *Hyperæmia.* It is customary to preface a chapter on the inflammation of an organ with a short description of the pre-inflammatory stage known as hyperæmia—an excess in the normal blood-supply. If the determination of this excess after death in a highly vascular organ, such as the lung or brain, calls for careful discrimination on the part of the pathologist, it may be supposed that the difficulty is still greater in the case of the ovary, which is subject periodically to an engorgement that, in any other organ, would be legitimately regarded as pathological. One of the immediate consequences of excessive congestion is rupture of a blood-vessel and hæmorrhage, either circumscribed (follicular), or more extended (into the stroma).

Etiology.—Pathological hyperæmia of the ovary is doubtless, as a rule, simply an increase of the normal monthly engorgement, consequent upon an obstruction to the venous circulation from local or general causes.

The delicate adjustment between the afflux and efflux of blood may be disturbed by numerous mechanical causes, prominent among which are compression of the vessels by surrounding adhesions, displacements of the pelvic organs, morbid growths, etc. Chronic oöphoritis is at once a cause and a result of hyperæmia. Any causes which determine a frequent and sudden flow of blood to the gland during the intermenstrual period (prolonged sexual excitement, violent or excessive intercourse, etc.) also favor this condition. It may be inferred that masturbation must exert a most pernicious influence in this direction.

Anatomy.—The following is a brief description of an ovary which I regarded as hyperæmic. Immediately after its removal by laparotomy it was slightly above the average size, well-rounded, of an elastic, almost fluctuating feel, and a purple-red color. On median section its cut surfaces presented a moist appearance and a deep pinkish hue, while the blood-vessels stood out with unusual distinctness, like the *stellulæ Verheynii* on the surface of a congested kidney. Further examination of the stroma showed that it was in a quasi-œdematous state, similar to that sometimes observed in a soft, fibro-myxoma. A comparison between the organ and a so-called "wet brain" suggested itself, and it seemed as if there might be some similarity in the etiological factors in the two cases. The information afforded by a microscopical examination was rather negative; there were evidences of vascular dilatation, both in the lymphatic and blood-systems, and a few extra-mural collections of corpuscles, such as might have been found in any other vascular organ under similar conditions, but the impression left by the entire examination was that, after all, it was doubtful whether the ovary presented any external or internal evidences of engorgement more marked than would have attended the ordinary menstrual nisus.

Clinical History.—Mr. Tait, with his accustomed felicity of expression, says: "Ovarian hyperæmia is the result of an over-sufficient, and generally precocious, ovarian activity . . . it is invariably well-marked in its history, the chief detail of which will generally be found to be *menorrhagia*." It is obvious that a young girl, whose ovaries are thus over-active, is liable to have chronic ovaritis, which may render her an invalid for life. It is doubtful if pure ovarian hyperæmia can ever be positively diagnosticated, except by inference, as associated with general pelvic engorgement. There are no symptoms sufficiently characteristic to distinguish the temporary condition from actual disease of the gland. When a young girl, especially one of an ardent temperament, who is free from pain in the intermenstrual period, suffers every month with throbbing pain in the ovarian regions, which are tender on deep pressure, accompanied by a profuse flow, it may be inferred that the ovaries are subject to excessive congestion; or a delicate young woman, with no previous history of pelvic trouble, soon after her marriage to a vigorous husband develops the same general symptoms—pain in the region of the ovaries, especially marked during the menstrual flow, which has become excessive, dyspareunia, and even hæmorrhage after each repetition of the sexual act. In the latter case, as in that of young prostitutes, who indulge in frequent and violent intercourse, hyperæmia "passes insensibly into chronic ovaritis."

Diagnosis.—This will be supported by the history of the patient, the principal facts being the ovarian pain at the menstrual epoch and its absence, or remission, during the interval, and the evidence of general pelvic engorgement afforded by the profuse flow. Age, temperament, physical condition, habits, environment, etc., should be duly considered. The result of a local examination is often either negative or doubtful; abnormal conditions of the uterus or its surroundings may be found, sufficient to account for the supposed ovarian trouble. For obvious reasons it is seldom possible to make a thorough examination at the time when the condition of the ovaries is most interesting from a diagnostic point of view, *i.e.*, during menstruation.

Prognosis.—It is especially favorable in the case of young girls, provided that they are not neglected too long after the menstrual function has become regularly established. In married women the prospect is less encouraging, because of the disturbing influences to which they are exposed and the difficulty of obtaining perfect physiological rest for them. In some instances pregnancy exercises a curative action, but more often the lesions resulting from parturition (laceration of the cervix and consequent subinvolution) tend to aggravate the existing congestion. The history of many cases of chronic oöphoritis shows conclusively that periodical hyperæmia formed the starting-point for the organic changes.

Treatment.—Although this varies with the age and condition of the patient, it is essentially hygienic. The first object to be aimed at is to ascertain the true cause of the ovarian disturbance. If the patient is immature great care should be exercised that her mind is not cultivated at the expense of her body; during the early months of puberty she should not be confined in school all day, but the hours of study should be shortened, if not abolished entirely, and she should take plenty of out of door exercise. While her general health is to be carefully attended to, particular care must be taken to eliminate every source of sexual excitement, such as might be found in improper books, plays, society, late hours, etc. Delicate as the subject may be, the physician should not neglect to inform himself regarding the practice of vicious habits by his little patient. Masturbation is at the bottom of many puzzling manifestations of hyperexcitability in children, male and female, which are vaguely ascribed to "nervousness." Treatment directed to the pelvic organs is mainly expectant. Insist on perfect rest in bed before and during the menstrual flow. Ergot or hydrastis canadensis, may be given for the menorrhagia, the bromides to allay ovarian irritation. A fly-blister over the tender ovary will be beneficial. Local treatment at this stage, other than the use of hot injections in exceptional cases, is not to be thought of; it would not only be useless, but harmful. Arsenic and strychnine are more useful than iron as general tonics. Ovarian hyperæmia in an unmarried female who has reached maturity is frequently an expression (though unknown to her) of ungratified sexual instincts; for such women matrimony is a natural relief, and should be recommended, provided that no local disease is present which would be aggravated by that condition. If marriage is impossible, a moral cure must be attempted. The patient should be encouraged to sink the emotional side of her nature in the practical, to go into society, to interest herself in anything and everything outside of herself. Medication is of secondary importance, moral suasion being the main agent to be employed.

For the third class, or married women, the object aimed at is in effect the same—the elimination of all influences which favor pelvic congestion. Such patients are treated most successfully in private institutions, rather than at their own homes, since the suspension of marital relations and entire freedom from domestic care are absolutely necessary. The treatment is essentially that of ovaritis; indeed, in most of these women who apply for relief the pre-inflammatory stage has already been passed.

Hæmorrhage into the ovary is a condition which possesses more of a pathological than a clinical interest, so that we need not consider upon it here.

(b) Acute Oöphoritis. Acute inflammation of the ovary presents variations both in its extent and in its intensity. It may be confined to a few of the peripheral ovisacs and their neighborhood, or may involve the entire stroma. It may be represented merely by an excessive hyperæmia with resulting serous effusion, or may culminate in general necrosis of the tissue.

Peri-oöphoritis, or inflammation of the peritoneum in the immediate vicinity of the ovary, is sometimes described as if it were a separate disease. It is simply a localized peritonitis, sometimes of primary origin, but more often secondary to disease of the appendages, especially of the Fallopian tubes.

Etiology.—"Acute inflammation of the ovary," according to Professor Goodell, "rarely exists *per se*, but

it is by no means an infrequent accompaniment of pelvic peritonitis and pelvic cellulitis, the cause of each being the same." Doubtless many cases of acute primary oöphoritis fail to be recognized, because the symptoms are masked during the height of the disease, which either rapidly subsides or passes into the subacute or chronic form.

The ovary may become inflamed from either external or internal causes; in short, the inflammatory process may be, so to speak, centripetal (secondary to inflammation of the tube or peritoneum) or centrifugal (beginning in the interior of the organ and extending outward). By grouping all of the causes under these two general heads, the question of etiology will be greatly simplified. Thus Tait refers acute oöphoritis to four conditions—direct injury, gonorrhœal infection, puerperal sepsis, and acute exanthemata (including rheumatism); the first two may be regarded as external, the last two as internal, causes. As Olshausen suggests, gonorrhœal poison, transmitted through the uterus and tubes, is only indirectly the cause of oöphoritis, since it gives rise to peri-oöphoritis, the ovary being affected secondarily. Inflammation of the follicles is not rare in acute febrile diseases, septicæmia, phosphorus-poisoning, etc., under conditions in which general destruction of the glandular organs is observed. General interstitial inflammation of the ovary is declared by most writers on gynæcology to be exceedingly rare outside of the puerperal state. Increased opportunities for studying diseased ovaries during the past few years, afforded by the frequency of laparotomies, have led to some modification of this opinion. In my experience it is not unique to find an abscess of the ovary associated with pyosalpinx.

Strangely enough, cold, sudden suppression of the menses, and other causes of pelvic congestion, are regarded by Olshausen as rarely accountable for acute oöphoritis; considering the uncertain boundary which separates intense hyperæmia from inflammation, we should certainly expect to meet with transitory forms of the disease as the result of such accidents. Sexual excesses must sometimes produce disturbances in the delicate organ more serious than simple congestion.

Gross Anatomy.—An ovary which is the seat of follicular inflammation does not usually show any marked changes macroscopically; in fact, the deviations from the normal may only be detected by the microscope. Enlargement of the organ is often inappreciable. In the lesser forms of the affection the contents of a few of the more peripheral primordial follicles may appear turbid; the older ovisacs may be affected later, and finally, the stroma immediately surrounding them, as shown by the rings of congestion. In interstitial oöphoritis the gross appearances are quite different. The ovary may be enlarged to several times its normal size, and have a soft or fluctuating feel (abscess). On section the picture varies with the intensity of the inflammatory process, from the congested and œdematous appearance described under Hyperæmia to the general disintegration in so-called *putrescentia ovarii*. Yellowish streaks of pus may be seen crossing the field or forming minute collections in the midst of the stroma, while here and there are small extravasations of blood. Finally, in the worst forms of oöphoritis, one or more abscesses, as large as marbles, containing a brownish, acrid fluid, may be present, or the entire organ may be transformed into a foul, sloughing mass which breaks down under the touch. It is hardly necessary to add that in such general inflammations of the stroma the ovisacs do not escape, but undergo changes similar to those in follicular oöphoritis.

Minute Anatomy.—The epithelium of an inflamed vesicle undergoes cloudy swelling and granular degeneration; the turbid, puriform appearance of the *liquor folliculi* is due to the presence in it of numbers of these cast-off epithelial cells. The contents of the ovum undergo a similar change, while the germinal vesicle disappears. Sections of an ovary which is the seat of acute interstitial inflammation show general stasis and vascular dilatation, small extravasations, and an irregular distribution of leucocytes throughout the stroma, with occasional collections of such cells in the interspaces—in short, the ordinary appearances seen in inflamed connective or fibro-muscular tissue.

Clinical History.—Authorities agree in affirming that acute oöphoritis presents no characteristic symptoms by which it can be distinguished from a localized peritonitis. When we consider the frequent association of tubal and ovarian disease, the subject becomes still further complicated. Acute interstitial inflammation, especially when resulting in abscess-formation, might present such phenomena as the following: A young woman during menstruation is suddenly seized with violent shooting pains in one iliac fossa (usually the left), extending through to the loins, while the flow is suppressed. The pain is of the peculiar agonizing character which has already been described as "ovarian," and although it may seem to be identical with that caused by localized peritonitis, it is apt to be attended with those reflex neuroses (pelvic, mammary, etc.) which so often accompany affections of the ovary. The patient lies on her back, with the knee drawn up on the affected side, the abdomen moderately distended, and the facies expressive of the most acute suffering. The lightest pressure over the seat of pain is resented, as shown by the instant rigidity of the abdominal muscles. Micturition and defecation are impossible, or extremely painful. It is evident that the pressure of the rectal contents against an ovary which is acutely inflamed will give rise to excruciating agony such as would not be observed in simple peritonitis. Note the presence of pain in the corresponding *breast* and *leg*, as a point of importance. The pulse and temperature present the usual characteristics of pelvic peritonitis; in fact, the reader will recognize the symptoms mentioned as fairly typical of the latter condition. The peritonitis may be limited to the region of the ovary (peri oöphoritis) and may rapidly subside, so that the patient is convalescent within a week; indeed, it is very common to find, on questioning women with evidences of localized peritonitis, that they have had several attacks which were, however, of such short duration that they will deny that they have ever had "inflammation of the bowels," and will only recall certain occasions when they were obliged to remain in bed for a few days at the time of the monthly period and suffered with severe pains in the abdomen, tympanites, etc.

According as the oöphoritis or the peri-oöphoritis is the predominating inflammation, the subsequent history of this hypothetical case will be that of general peritonitis or pelvic abscess; in short, the peri-oöphoritis may lead to a general inflammation of the peritoneum, or the ovary may suppurate and become an abscess, which may discharge its contents into the rectum, bladder, or vagina, or may undergo caseation and gradually disappear.

A peculiar phenomenon, rarely observed, is the alternation of acute oöphoritis with parotitis, analogous to the sympathetic inflammation of the testicle in mumps; as the swelling in one gland subsides, the other becomes affected, so that both may suppurate. The value of this curious complication in connection with the diagnosis of suspected ovarian disease is evident.

The vagueness of the foregoing description is painfully apparent. No attempt has been made to distinguish symptoms referable to tubal disease, since this would only have added to the difficulty of the subject; for this reason no mention has been made of those recurrent attacks of ovarian inflammation which seem to be of gonorrhœal origin, because the tubes really bear the brunt of the specific poison and are more liable to such recurrences. The reader will infer that it is only in exceptional cases (especially in pyæmia) in which the ovary seems to be primarily affected that the accompanying peritonitis does not obscure the evidences of oöphoritis.

Diagnosis.—One point in the clinical history has been emphasized as affording a clue to the seat of the inflammation—the *pain*. Its location is not absolutely pathognomonic, although it is commonly so regarded; but the character of the pain (sharp and stabbing), its sudden onset, the infra-mammary neuralgiæ which accompany it, the absence of any definite signs of peritonitis at the outset—

these should direct us to the ovary as the probable seat of the trouble. But, if we do not see the patient until either well marked peritonitis or abscess formation has obscured the original condition, we can hardly hope to make a positive diagnosis.

The peri oöphoritis which obscures the subjective symptoms renders the physical examination extremely difficult and unsatisfactory, at least during the height of the inflammation. There is, practically speaking, no necessity for the general practitioner to establish definitely the presence of ovarian inflammation, since the treatment will not be modified by the greater accuracy of the diagnosis. But if the surgeon desires to gain precise information with a view to performing laparotomy, the patient must be examined under ether. The case with which the pelvis can be explored during an attack of acute peritonitis is often described, but is seldom realized at the bedside when we attempt to practise the bimanual method with the abdomen either rigid or tympanitic. In a favorable case, having placed the patient on the side, gently insert the right index-finger into the hot, dry vagina and explore the posterior and lateral pouches. Behind, and generally to the left of, the uterus will be felt a rounded body, apparently as large as an English walnut, extremely tender to the touch, and either fixed or but slightly movable; it may be possible to detect in it an obscure fluctuation. A rectal examination sometimes furnishes valuable information. An ovarian abscess of the ordinary size (not larger than an orange) will present the same sensation to the examining finger as a small cyst, the clinical history and the symptoms of acute suppuration indicating that its contents are purulent. The differential diagnosis between acute oöphoritis and salpingitis is only interesting to the specialist, and even by him it often cannot be made positively. In general, it may be said that the former is an acute, the latter a subacute inflammation; moreover, the latter is apt to be recurrent, while acute oophoritis tends to terminate by suppuration, or to pass rapidly into the chronic stage; subsequent attacks of inflammation, if they occur, being due rather to the lighting up of a slumbering peri-oophoritis, than to the renewal of active trouble in the interior of the ovary. The relation between tubal disease and recurrent peritonitis has already been remarked. There are doubtless cases in which we can affirm positively, from the peculiarly elongated, tortuous shape of a retro-uterine tumor, felt *per vaginam*, that it is an enlarged tube; but quite as often it is impossible to determine, from the shape, whether the mass is an enlarged ovary, or tube, or both combined. Again, the question may arise as to whether a fluctuating tumor occupying the site of the ovary is a true ovarian abscess or a suppurating cyst, especially a dermoid cyst. If an enlargement was known to exist *before* the advent of the acute symptoms, the diagnosis is easy; otherwise, it would turn upon the sudden development of the inflammatory process in oöphoritis as compared with the subacute inflammation within a pre-existing cyst. It will at once occur to the reader that it must be very difficult to differentiate between a small pelvic abscess and one confined to the ovary. Here a careful vaginal examination is most important. Both enlargements give a sensation of fluctuation, but the ovarian tumor is rounded, quite sharply defined, and often movable, with more of an elastic feel, while the pelvic abscess is seldom circumscribed, but shades off gradually into the surrounding indurated tissue. It is either perfectly fixed, or moves only as the uterus and vaginal fornix are elevated: the latter, it may be added, bears a close relation to a pelvic abscess. The walls of the latter being thicker than the capsule of a suppurating ovary, it has a doughy, rather than an elastic, feel. Small inflammatory foci in the broad ligaments, however, are not so readily distinguished. After either abscess attains a large size, the most acute diagnostician, unless he had watched its progress from the outset, would hardly pretend to decide whether it originated in a tube, in an ovary, or in the cellular tissue. The aspirator sometimes throws light upon a doubtful diagnosis. When a fluctuating tumor is accessible through the posterior fornix a long *aseptic* needle may be introduced into it, and a few drops of fluid withdrawn by the hypodermic syringe for microscopical examination.

An *ex post facto* proof, as it were, that an acute attack such as we have described was really oöphoritis, is afforded by the subsequent history of the patient. If she presents the symptoms and physical signs of chronic ovarian disease in the gland formerly affected, it may be assumed that she did have acute oöphoritis, which has terminated, not in suppuration, but in a cirrhotic condition, to be described later.

Prognosis.—This should always be guarded, since, although the patient may recover from the acute attack, her ovary has been permanently crippled and will inevitably give rise to future trouble. Even if the gland itself has only been "scorched," as Dr. Emmet expresses it, by the surrounding peritonitis, the latter inflammation results in the formation of adhesions which fix the organ (often in an abnormal position) and make it eventually the source of misery to its possessor. Acute inflammation of the ovary is always a grave affection, which may speedily reach a fatal termination through general peritonitis—secondary to peri-oöphoritis or to the rupture of an abscess, the former being the principal danger in non-puerperal oöphoritis. In looking over the reports of cases of suppurative inflammation of the ovary, one is struck with the frequency with which the abscess ruptured into the peritoneal cavity; this is probably due to the fact that, unless it is of large size, it does not come into such direct relation with any of the channels through which the contents of a pelvic abscess usually find exit (rectum, bladder, vagina, etc.). The rectum is the most common seat of perforation. Many cases have been reported in which the contents of ovarian abscesses were absorbed, their sites being subsequently marked by cystous masses or cicatrices. Death may result from chronic septic poisoning either before or, more often, after the abscess has ruptured externally.

What future shall we prophesy for a woman who has recovered from an attack of acute ovarian or peri-ovarian inflammation, with or without suppuration? We certainly cannot truthfully promise her freedom from future trouble; on the contrary, she has within her pelvis the smouldering embers of a fire that may at any time be easily fanned into a flame. She will be remitted every month, if not more frequently, that her ovaries are not what they should be. Sterility is the usual result if both ovaries are affected.

Treatment.—This is essentially the same as that employed in pelvic para- and peri-metritis. Absolute rest on the back must be insisted on; the patient will be made most comfortable by bending her knees and placing a pillow beneath them. Blistering the skin over the iliac fossæ is the routine treatment, but what possible good this can accomplish it is difficult to discover, while it adds materially to the patient's discomfort. Hot flax-seed poultices, renewed as soon as they become cold, with three or more copious vaginal injections of hot water daily, certainly give relief and possibly reduce, to some extent, the general pelvic congestion. Leeches may be used, also vaginal poultices, consisting of small bags filled with flaxseed meal, poppy-leaves, etc. Morphine should be given hypodermatically in sufficient doses to relieve pain; antipyrine or quinine, with the abdominal ice-coil, are indicated if the temperature runs above 102° F. It has sometimes seemed to the writer as if a peritonitis could be prevented from extending above the pelvis by the early and persistent application of cold to the abdomen. After suppuration has begun this agent is of course useful only as an antipyretic, and the ice-cap may be employed then instead, if preferred. Liquid diet is preferable, especially milk, and stimulants should be given only when the necessity is indicated by the pulse. The bowels may be moved by enemata at intervals of a few days, unless the tympanites is excessive, when we should insure the patency of the canal by the early use of turpentine injections. Evidences of abscess-formation should be anxiously watched for, and when pus is present it should be withdrawn by the aspirator-needle introduced into the sac through the vaginal roof. After the evacuation of its

contents the cavity should be thoroughly irrigated with an antiseptic solution.

It will naturally occur to the reader to ask if this is all. Shall we rest content with simply treating the symptoms, or does not modern surgery offer a bolder method of striking at the root of the trouble? The following quotation from the eminent Birmingham surgeon indicates the tendency of laparotomists: "In the event of the attack appearing to threaten the life of any patient under my care, I would not hesitate to open the abdomen, cleanse out the cavity, and possibly remove the diseased organs. When an ovarian tumor is gangrenous or suppurating, we serve the patient by promptly removing it, and I do not see why this principle should not be extended. The result of the disease is nearly always to destroy the functions of the glands, and, therefore, in prospect of a fatal issue of the disease, the argument against an operation, that it will unsex the patient, need not be considered."

(c) *Chronic Oöphoritis.* It is difficult to define this condition without describing it as at once a cause and an effect—an inflammatory process and an anatomical change in the structure of the gland. It is rather an "end-process" (to use a Germanism), a condition of the ovary resulting from acute or subacute inflammation, characterized anatomically by an overgrowth of fibrous tissue, at the expense of the normal stroma, with or without enlargement of the ovisacs. Either cirrhosis, with resulting atrophy, fibroid enlargement, or cystic degeneration, may be the predominating change.

Etiology.—Dr. Goodell refers to chronic oöphoritis as "a very common form of disease, very rarely coming from an acute attack, but starting subacutely, with all the symptoms of chronicity." Olshausen expresses substantially the same opinion, with the qualification, however, that "perhaps the acute oöphoritis was latent." Fontana in one hundred and forty-five cases traced the chronic changes to a previous acute inflammation in thirteen per cent. While we may seldom succeed in obtaining a clear history of acute ovarian or peri-ovarian inflammation, it does not follow that the sequence is so rare as Dr. Goodell affirms. The fact that Tait regards cirrhosis as a "sequela of exanthemata and rheumatic fever" in early life, indicates that his wide experience has led him to a similar conclusion. Subacute or chronic inflammation of the ovary is essentially the result of persistent hyperæmia, the causes of which have already been mentioned. As regards its frequency, different observers have noted its occurrence in from 1 to 4.75 per cent. of all pelvic affections. Fifty-eight per cent. of the patients are between the ages of twenty and thirty years, the majority being young married women, although the unmarried form no inconsiderable proportion of the sufferers. Among the former it is only necessary to mention the influence of sterility (especially when self-induced), frequent and violent, or imperfect intercourse, specific infection, etc.; the *colica scortorum* of youthful prostitutes is symptomatic of the ovarian disease which results from their unnatural sexual relations. The lesions and displacements referable to parturition produce a condition of lasting, or recurrent, pelvic congestion which naturally exerts a baneful influence upon the susceptible glands. Emotional causes are most active in single women, whether they lead to vicious habits (self-abuse) or to unsound mental conditions. Matthews Duncan refers to suppression of the menstrual flow (from cold, dancing, or sexual excitement) as a frequent etiological factor; he also mentions alcoholic excess as a common cause. The more frequent involvement of the *left* ovary has been noted elsewhere.

Gross Anatomy.—As viewed *in situ* on the post-mortem table, an ovary that is the seat of chronic inflammatory changes may be either movable or buried in a mass of adhesions; it may be found at, or slightly below, its normal plane, or at the level of the pelvic floor, adherent to the base of the broad ligament, the uterus, or the rectum. The corresponding tube may be normal, or may exhibit the enlargement due to salpingitis; its fimbriated extremity may be slightly adherent to the ovary, or the two may be inextricably glued together in the manner so familiar to the laparotomist.

Three types of ovary are presented, the peculiarities of each being sufficiently evident on gross inspection, although two of these may be readily confounded with normal glands. Interstitial or follicular changes may predominate, the latter leading to more or less marked enlargement of the organ, the former often to diminution of its size. A cirrhotic ovary is smaller than normal, hard and non-elastic, and so nodulated that it reminds one of a "hob-nail" liver. The pinkish, or pearly hue of the healthy gland has given rise to the whitish, cartilaginous appearance of the thickened cortex. Now, comparing a purely cirrhotic ovary with one that has undergone normal senile atrophy, the anatomical identity of the two will appear most striking, and will compare well with their functional condition—one being prematurely, the other actually, senile. The exanthematic atrophy of Mr. Tait is a typical example. However, aside from the difference in the age and sexual history of the two subjects from whom the above-mentioned specimens were removed, there will usually be evidences, even on gross inspection, that the cirrhosis in one instance is due to an actual inflammatory process, which has not resulted in such uniform contraction of the organ as that due to simple atrophy. Moreover, the presence of peripheral cysts, peri-oöphoritis, etc., will point to the true condition. On section a cirrhotic ovary offers the same resistance to the knife as a small fibroma; the cut surface suggests the same analogy. It presents an almost homogeneous fibrous structure, bundles of such tissue interlacing in all directions, with here and there a shrunken ovisac embedded in it. The cortical zone is dense and semi-cartilaginous, while the entire aspect of the surface appears dry and non-vascular, offering a decided contrast to the moist, pinkish stroma of the normal gland. Such an ovary as the one described represents the extreme type of cirrhosis. Every intermediate stage of this condition is observed in specimens removed by laparotomy; localized thickenings of the capsule or stroma, partial atrophy (both interstitial and follicular) of portions of the gland, with functional integrity of the remainder, crippling of one-half by surrounding adhesions, while the other half appears to be discharging its ova in the usual manner—all these pathological appearances are familiar. Moreover, cirrhosis may be only one element, cystic degeneration being present at the same time, so that, while a part of the ovary is atrophied, another is enlarged from hypertrophy of its follicles; this is regarded by some as a separate type. But an increase in the fibrous tissue does not necessarily imply atrophy; fibroid hypertrophy is a well-recognized condition which is particularly interesting from the close relation that it bears to true fibroma of the ovary; indeed, the writer believes that in some instances the latter variety of ovarian tumor is simply the result of excessive development of the fibrous stroma. Instead of appearing as a scarred, shrunken body, less than one-third of its normal size, a gland which has been the seat of so-called hyperplastic oöphoritis looks not unlike a small subperitoneal fibroid; a typical specimen is about the size of a pullet's egg, presents a smooth, often quite regular, surface, and a firm, homogeneous consistence, all traces of the ovisacs having disappeared. Such ovaries are frequently perfectly movable, and show no evidences of any previous surrounding inflammation, such as commonly accompany the atrophic form. Either all vestiges of the Graafian vesicles have disappeared, or those which remain form mere pits in the midst of the dense fibrous tissue.

"Cystic degeneration" of the ovary is an expression that has come to be used very loosely, sometimes, it must be confessed, to excuse the removal of organs that could not fairly be considered as actually diseased. The appearance of a few slightly enlarged vesicles on the exterior of an ovary, otherwise of normal size and appearance, hardly justifies us in applying to it the term "cystic;" it should rather be limited to those specimens in which the gland is enlarged (sometimes to thrice its usual dimensions), and presents on its exte-

riot either several from twelve to fifteen cysts, varying in size from a pea to a small marble, or, it may be, two or three larger ones, while on section the deeper ovisacs are seen to have become enlarged at the expense of the stroma. Sometimes a single cyst in the interior of the gland reaches the size of a pigeon's egg, so that the question may well arise, whether we should not regard the condition as true ovarian cyst, rather than simply as cystic degeneration. The term *hypertrophy of the Graafian follicle* is sufficiently comprehensive to include all grades of enlargement which are represented by dilatation of a Graafian body, with increase of its clear, watery contents. The main point to be remembered is this—a "cystic" ovary is one in which there is a manifest tendency to general enlargement of the ovisacs, both central and peripheral, at the expense of the stroma, the latter being commonly the seat of cirrhotic changes especially in the neighborhood of the diseased vesicles. In rare cases the entire gland may be transformed into a mass of cysts, like the kidney under similar conditions. In this instance it becomes difficult to characterize the enlargement, which may reach the size of the fist, or even of a man's head. The contents of the cysts is a watery fluid that shows no evidences of an inflammatory origin. Tait has called attention to the frequent occurrence of peri-oöphoritis in connection with this form of chronic ovarian disease. The association of these three varieties of chronic changes is the rule rather than the exception; indeed, it is rare to meet with a pure form of either follicular or interstitial oöphoritis. This fact renders it impossible for one to give a description of a single specimen such as will apply to all. No two ovaries, whether normal or pathological, are exactly similar. In one specimen interstitial changes may predominate; in another, follicular. Because it is described as "cystic," it does not follow that an ovary is not also the seat of both cirrhosis and hypertrophy; indeed, one portion of the gland may be shrunken, while another is enlarged; one region may be rich in cysts, while another presents a homogeneous fibrous tissue without a single vesicle. The possible variations in the size, shape, and external and internal appearance of different ovaries are innumerable; all show the results of the same process, but in different degrees and differently distributed.

Minute Anatomy.—From what has been said, it will be evident to the reader that the microscope often reveals slight pathological changes in the ovary which were not apparent on careful macroscopical inspection, and which, as far as could be ascertained, never gave rise to any recognized symptoms. In order to avoid details uninteresting to the general reader, only the more obvious changes will be briefly mentioned.

Among the various appearances to be noted in a microscopical section of a chronically diseased ovary, the most striking is the transformation of the stroma into a dense fibrous mass, which, from its non-vascularity, often resembles cicatricial tissue; this may exist in spots or throughout the entire field. The arteries sometimes show circumscribed dilatations, but more often they are the seat of endarteritis, with contraction of their lumina. Amyloid degeneration of the middle coat has been described. The cortical zone is particularly fibrous and non-vascular. As regards the Graafian vesicles in aggravated cases, they may have entirely disappeared, being represented either by cysts with thickened walls, by pits or depressions in the midst of the homogeneous tissue, or by small collections of degenerated cells or confused masses of granular débris. If subacute inflammatory processes were present in the ovary, they will be indicated microscopically by dilatation of the vessels, blood-stasis, and interstitial collections of leucocytes. Traces of former hæmorrhages are sometimes seen, in the shape of masses of blood-pigment.

It is not proper to judge of the condition of an ovary from the examination of a single section. While one may present evidences of extensive morbid changes, another, cut from a different portion of the same ovary, may vary but little from the normal—the stroma, and even the ovisacs, being intact.

Clinical History.—Patients with this affection do not generally recall any definite time at which it began; it is characteristic of the disease that its onset is gradual. Some women may insist that their troubles commenced with the establishment of menstruation, while others, who have never borne children, refer their ovarian symptoms to the early months after marriage; arrested involution after childbirth is apparently responsible for many cases of chronic oöphoritis, to judge by the frequency with which the beginning of the ailment is referred to that time. Sometimes we succeed in obtaining quite a clear history of a previous attack of subacute inflammation after a sudden suppression of the menses, from which time the patient was never quite as well as before, gradually becoming worse and worse, until she presented all the symptoms of advanced ovarian disease. But when we are consulted with regard to such disease, it is the present symptoms, and not the probable cause of the trouble that concern us as well as the patient. The symptom from which she desires relief is *pain*, and pain of a peculiar nature. Unlike the dragging, aching pain in the back and abdomen, which is not constant but is increased on exertion, that due to ovarian disease is of a peculiar, sharp, darting character, is clearly localized in one or both groins (especially the left), becomes more severe when the patient stands and walks, and is usually accompanied by certain reflex phenomena that point strongly to its origin. Add to this the well-marked exacerbation which occurs at the menstrual period, and there can be little doubt as to what condition we shall find on making an examination. The special symptoms produced by prolapsed ovaries (especially pain during defecation) have already been described. There exists every shade of difference as regards the intensity of ovarian pain. We not infrequently find, at the examining-table, enlarged and prolapsed ovaries that not only cause little or no discomfort during locomotion, but do not even give rise to marked dysmenorrhœa; the patient may occasionally pass through a period with little discomfort. More commonly the pain is severe and almost unremitting, being relieved only by perfect rest in the recumbent posture; it begins in the ovary and frequently radiates to the back and down the thighs. Reflex neuralgiæ are common, pain in the breast on the corresponding side being especially frequent. The pain is sometimes of a sharp, sickening character, although this peculiarity is more marked when pressure is made upon the diseased organ. Dyspareunia is present in a large proportion of the cases, for obvious reasons. But since the explanation is a purely mechanical one, it follows that, when the vagina is long or the diseased organ has not sunk to the bottom of Douglas's pouch, marital relations may not be attended with discomfort. Stress is laid on this, because the reader must necessarily infer, from reading some of the text-books, that chronic oöphoritis always renders intercourse unendurable. Dysmenorrhœa is the most serious consequence of ovarian disease, and the one which may make the patient's life a burden to her. The pain in the affected gland is most severe a few days before the monthly flow, and reaches its acme just before the latter begins, when it is usually relieved, but does not disappear entirely. It is sometimes of the most agonizing character, suggesting renal colic, so that the most courageous woman becomes frantic, and begs for relief at any price. Patients often describe their sufferings as far exceeding those of labor; with due allowance for the hysterical element in these cases, it cannot be denied that the spectacle presented by a woman writhing in the agony of ovarian dysmenorrhœa is pitiable in the extreme. All theories as to the true cause of this pain must be purely speculative; it is doubtless largely of a neuralgic character, but whether the extra- or intra-ovarian nerves are most affected is, of course, unknown, and doubtless always will be. We may imagine that the terminal filaments are irritated within the stroma, or that the thickened cortex of a cirrhotic ovary prevents it from enlarging under the influence of the monthly congestion, or that, for the same reason, the Graafian bodies have a hard struggle before they can force their way through the cortex and discharge

their contents. Or, reasoning from cases in which the ovaries are only slightly diseased, but are surrounded by adhesions from a former peri-oöphoritis, we may ask, "Are not these adhesions responsible for much of the periodical, as well as the persistent pain?" I believe that this thought is a most suggestive one, and that we may yet be able to localize the pain more nearly than we can at present. Disease of the corresponding tube may complicate the ovarian trouble, but it does not mask the characteristic pain.

The character of the menstrual flow deserves some consideration. Sometimes it presents no deviation from the normal, but more often it is either increased or diminished. Menorrhagia is frequently present, and may persist until after the usual time for the climacteric, though it may appear only in the early stage of the affection, the flow becoming subsequently irregular and scanty. Mr. Tait believes that hæmorrhages are more common in connection with the follicular form of oöphoritis, although he attributes them mostly to "fundal metritis and inflammation of the tubes." It is fair to assume that the menorrhagia is in many instances simply an expression of the general pelvic congestion, in which the ovary shares, rather than a phenomenon which is directly due to ovarian disease. Scanty and irregular menstruation, and even temporary or permanent amenorrhœa, are not infrequently noted in connection with cirrhosis of the ovaries. The pain is most severe in these cases. In other words, the patient enters upon the change of life prematurely. Sterility is an inevitable consequence of disease of both ovaries, and often exists when apparently only one is affected, but we must be careful how we deliver a prognosis in the latter cases. It is obviously impossible, in a hasty sketch like the present, to enter into a consideration of the complex subject of so-called "reflex neuroses." Attention has already been called to those referable to the bladder, rectum, and breast. Migraine, so-called "spinal irritation," dyspepsia, flatulence, and frequent nausea and vomiting, are lesser evils, while epilepsy and insanity form the final links in the chain. The connection of these symptoms with the ovarian disease is not always clear, and a careful study of the case should be made before we decide positively. The important point to note is, of course, the effect of the menstrual nisus upon the various symptoms, especially the nervous and psychical. We cannot dwell upon the protean phenomena of hysteria; that their presence necessarily implies ovarian disease is an erroneous idea, although they are frequently associated with it. The important point in such cases is to estimate the symptoms at their proper value, since they are not necessarily all hysterical. A woman may really begin with an actual pain, and exaggerate it until its true character is masked. Charcot's experiment of producing and arresting hysterical attacks by pressure over the affected ovary is classical. Hystero-epilepsy should be carefully differentiated from true epileptic seizures, especially when the advisability of resorting to Battey's operation is considered. Only by studying carefully the character of the patient and her condition in the intermenstrual period, and by noting the *periodicity* of the phenomena, can their exact relation to the local condition be estimated.

Diagnosis.—From what has been said with regard to the character and periodical exacerbation of ovarian pain, as well as its site and the attending reflex manifestations, it is evident that the diagnosis of chronic oöphoritis is often practically made by the expert before resorting to a physical examination. A description of the method of procedure was given under the section on "Prolapse of the Ovary." Pressure in the groin over the affected organ causes sharp, often sickening, pain. By the bimanual method the ovary, if prolapsed, is distinctly felt by the finger within the vagina, or if not, it can generally be mapped out between the finger and the external hand. If necessary the patient should be anæsthetized. Although the apparent size of the organ as felt through the vagina is very deceptive, it can be estimated fairly well when the gland lies at the bottom of Douglas's pouch; an ovary that can barely be touched by the finger-tip usually appears to be about the size of an almond, when it may actually be two or three times as large. General cystic degeneration of the ovary can readily be detected in favorable cases, but it is doubtful if many fingers are sufficiently delicate to appreciate the minor degrees of hydrops folliculi. Fibroid enlargement of the ovary may be recognized by bimanual examination; the diagnosis of cirrhosis is usually made after the abdomen is opened. It is, of course, impossible to estimate the precise character of peri-oöphoritic adhesions, although their presence is indicated by fixation of a displaced ovary, as well as by marked tenderness in (or rather around) the organ.

The conditions to be distinguished from chronic oophoritis during the physical examination have already been mentioned under the section on "Prolapse," but they may be briefly recapitulated as follows: Small ovarian tumors, enlargement of the tubes, parametritis, subperitoneal fibroids, and ovarian neuralgia. From what has been said with regard to the limit between cystic degeneration of the ovary and small ovarian cysts, on the one hand, and between chronic fibrous hypertrophy (oöphoritis hyperplastica) and fibroma ovarii, on the other, it is evident that it is not always easy for the pathologist to decide when the specimens lie before him, so that it is clearly next to impossible to do so clinically. It may be said, in general, that while a patient with chronic oöphoritis invariably gives a history of some menstrual disturbance associated with characteristic ovarian pain, a small tumor frequently occasions no symptoms whatever. Moreover, the tenderness observed on palpation of a diseased ovary is seldom seen in cases of small ovarian cyst or fibroma, unless there has been recent peritonitis. Fluctuation in a small parovarian or ovarian cyst is more clearly marked than it is in the case of simple hydrops folliculi. Small subperitoneal fibroids with long pedicles often simulate fibroid ovaries, but the former give rise to few, if any, symptoms, and are painless on pressure. Their connection with the uterus can sometimes be clearly defined.

Parametritis may be acute or chronic; if the former results in the formation of an abscess, the shape, location, and fluctuation of the tumor, aside from the history, will serve to differentiate it from an enlarged ovary. Localized indurations, the result of peri- or para-metritic inflammation, are more diffuse, are less painful on pressure, and have in general a different location from prolapsed and enlarged ovaries. The relation of the induration to a lesion of the cervix can often be established beyond question. Such a condition may co-exist with disease of the ovary, where the diagnosis is often very obscure. This leads to the important question of the possibility of distinguishing ovarian from tubal enlargement at the examining-table; when there has been previous oöphoritis (or peritonitis), so that the appendages are buried in a mass of adhesions, it is often entirely a matter of guesswork. Is a rounded, or oblong, or "sausage-shaped" swelling a diseased ovary, or tube, or both? This is a question of great practical importance, and one which some have assumed to be able to answer without difficulty. Doubtless there are characteristic cases in which, from the symptoms, as well as from the physical condition, the exclusive diagnosis of oöphoritis or salpingitis can be made, but I have so often found the tube and ovary fused together in cases of pyosalpinx, that I believe it to be rarely possible to separate the two clinically.

Ovarian neuralgia, as has been said, is not only a very obscure affection, but we are not yet in a position to affirm that a large part of the pain in cases of ovarian disease is not of a purely neuralgic character. Certainly the *tactus eruditus* of the gynæcologist is not so delicate as to tell him where functional ovarian trouble ceases and organic disease begins. The occult changes within the gland that elude the microscope can hardly be appreciable to the finger-tip through half an inch of interposed tissue. We are only cognizant of gross abnormalities. If there is severe pain in an ovary, and on the most careful examination we find no evidences of enlargement, we content ourselves with the diagnosis "neuralgia;" if there

is enlargement, we attribute all the symptoms to chronic oöphoritis, and seek no further. Perhaps there was disease in the former case and a neuralgic element in the latter, or, perhaps, there were peri-oöphoritic adhesions that gave rise to some of the symptoms, especially to the pain.

The practical lesson is this—we can hardly affirm, positively, the exclusive dependence of a certain set of symptoms on disease of one or both ovaries until the patient has been under observation for some time, and has been examined more than once, under ether, if there is any doubt regarding the diagnosis.

Prognosis.—The prognosis, as regards the life of the individual, is good; death rarely occurs as a direct consequence of the disease of the ovary. In this respect there is a great difference between oöphoritis and salpingitis. That the disturbance of the diseased organ at the time of menstruation, the vascular obstruction, etc., may give rise to fresh attacks of localized peritonitis is quite possible; hæmatocele has resulted from such obstruction, but the actual sequence in these cases is always obscure. All that we can affirm is, that simple, uncomplicated chronic oöphoritis is rarely fatal *per se*. It remains to prognosticate the patient's future. We may, for convenience, consider the question anatomically and clinically. How long will a diseased ovary continue to enlarge, and is there any probability that it will ever form a tumor, cystic or solid? Much confusion has arisen from loose statements to the effect that *every* cystic ovary may become an ovarian cyst. Careful examination of a number of such ovaries at different stages of enlargement must convince the impartial student that while small unilocular ovarian cysts do arise by excessive distention of one or two central vesicles at the expense of the stroma, general follicular enlargement rarely terminates thus. It follows that our statements with regard to the further increase in size of an enlarged ovary should be marked by great caution, not to say indefiniteness. The small cysts may, and do, rupture, but seldom cause trouble—at the most, slight localized peritonitis. The possible relation of chronic hypertrophy of the ovary to true fibroma will be considered later. The patient naturally asks if her disease is curable. Our reply will be based upon the facts in the individual case, viz., the character and amount of the pain, the dysmenorrhœa, the possible co-existence of tubal disease, and the patient's general condition.

If the pain before the monthly flow is moderate, and disappears almost entirely in the interim, there being few, if any, reflex disturbances, while on physical examination the affected organ is found to be but slightly enlarged and not very tender—the prognosis for ultimate entire relief is good. Under careful regulation of her general and sexual habits, with appropriate treatment, there is no reason why the woman should not be cured, especially if there is a possibility that some uterine trouble may account for the principal symptoms. The prognosis, as regards permanent sterility, is an important one. A large proportion of the sterile women, with prolapsed and diseased ovaries, have also acquired antéflexion (doubtless the two displacements resulted from the same attack of peritonitis), and there is always ample room for doubt as to whether the uterine condition is not partly responsible for the dysmenorrhœa and sterility. In fact, I have recently seen two cases in which women, in whom these conditions existed simultaneously, fortunately declined the proposed laparotomy, and became pregnant after simple dilatation of the cervix.

More often we meet with women who are seriously crippled by their infirmity, seldom enjoying an hour when they are not reminded of it by an occasional twinge of pain, except when they are recumbent. They are unable to walk more than a block or two, tire easily, and look forward to the menstrual period with dread; in fact, one-half of the month is spent in enduring and recovering from it. Sexual intercourse is intolerable. The prognosis in these cases is not encouraging, but it is very far from being hopeless, as long as the patient can be encouraged to struggle against invalidism, and has not become hopelessly addicted to narcotics and stimulants. When one, or both, ovaries are prolapsed, and are so tender that the slightest pressure gives intense agony, and when, at every menstrual period, there are evidences of recurrent attacks of peritonitis that point to tubal disease, there is little hope of more than temporary relief from treatment. The prognosis in cases of epilepsy, hystero-epilepsy, and various other nervous troubles which appear to be confined to the menstrual period, and are due directly or indirectly to ovarian disease, is always a little uncertain, because of the difficulty of overcoming vicious habits, even after the original cause has been removed. When the menstrual function is hopelessly disturbed or destroyed, as shown by the scanty flow and subsequent amenorrhœa, the probability is that the tissue changes have become so general that the woman really is "unsexed," in the sense that she is in the same condition sexually as if she had no ovaries at all. The only question, then, to be decided is whether she will finally obtain relief from her distressing symptoms. In all probability she will grow rather worse than better, until she reaches the menopause. The prognosis, as before stated, varies with the patient, and especially with her social condition. While a lady of the upper classes may take to her bed and become an invalid, where her local trouble is really of only moderate severity, her humbler sister may increase her already serious condition by pursuing a mode of life which directly favors the aggravation of existing symptoms. In the former case the diseased ovary often remains *in statu quo* under the influence of rest and the avoidance of exciting influences, while the lady's general nervous condition grows worse and worse, often in consequence of the large amount of attention and sympathy which she receives; in the latter, the patient frequently continues to work until she is unable to bear up any longer, so that when she comes under our observation her local condition is beyond palliative treatment, while she may be far from being an invalid.

He would be a most superficial examiner who recognizes no difference, as regards the prognosis, between the diseased ovary, movable and not especially tender except on deep pressure, and the same organ when fixed by perimetritic adhesions, and so sensitive that the patient cannot bear the slightest touch. Without delaying longer upon this subject, it may be said, in conclusion, that to make a discreet prognosis in cases of ovarian disease requires wide experience, wise discrimination, and a conscientious desire to act for the best interests of the patient.

Treatment.—There is little to add to the local and general treatment of this affection as described in previous sections, the object of which is to secure perfect rest of the diseased organ and to relieve congestion. It is highly important to avoid sexual excitement, for obvious reasons. Doubtless much of the benefit received by patients during a long stay in a private hospital arises from the fact that they are freed entirely from their matrimonial duties, and are obliged to rest at the time of the monthly period. These hygienic measures, in addition to hot vaginal injections, applications of iodine to the vaginal fornix, and glycerin-tampons, often accomplish wonders, especially if combined with the judicious use of electricity, massage, and carefully regulated diet—in short, the system so successfully carried out by Weir Mitchell.

Of course, we should always seek to disabuse the patient's mind of the idea that she is an invalid; she must simply learn to take better care of herself, not necessarily to suspend entirely her pleasures and occupations. Every attendant at a clinic for diseases of women must be impressed with the fact that some patients with ovarian disease come to him month after month without apparently receiving the least benefit. Is it strange, when all the beneficial results of the treatment are more than neutralized by the fact that the patients continue to be exposed to the most unfavorable influences at home?

But even if we cannot cure these women of the lower classes, we can teach them to be more careful of themselves, and can make their lot more tolerable. They can rest a little, can use hot water, regulate their bowels, avoid excesses, and "favor" themselves at the time of

menstruation. Electricity often gives great relief to such patients. If the ovary is prolapsed, a suitable pessary may accomplish much. But it is in this class of cases that the question of operative interference will early present itself.

Of drugs it is hardly necessary to speak, since they will be used as indicated, iron and arsenic in the case of anæmic patients, and the various nervines according to the amount of faith which the reader possesses in the different remedies. We are always warned against resorting indiscriminately to the hypodermatic syringe in cases of ovarian dysmenorrhœa. It is easier to give than to follow this advice. Provided the physician has absolute control over the dosage, as well as over the patient, and withholds the drug when it is not needed (*i.e.*, after the acuteness of the pain has passed away), it is certainly better for him to administer a hypodermatic injection occasionally than to leave a woman to stupefy herself with brandy, as such sufferers frequently do. Let a patient with dysmenorrhœa have opium *when it is absolutely necessary*, but insist on her sending for you to give it to her. As soon as such a woman begins to drug herself, she is in danger.

The removal of the ovaries for the relief of chronic disease is too important a subject to be discussed here, even if the space permitted; the writer even questions the wisdom of touching upon it at all. A few statements may, however, be allowed, since we limit ourselves to the consideration of a single indication for "oöphorectomy"—actual ovarian disease. The glands, when removed for the relief of epilepsy or "ovarian insanity," to bring on the premature menopause in cases of fibroid tumor, or in connection with salpingitis, may of course be diseased, but under these circumstances there is no definite purpose of ablating the ovaries for the primary reason that they are morbidly affected; moreover, they may retain their functional integrity even though associated with the above-mentioned conditions. If we assume, with Olshausen, that pain and dysmenorrhœa are sufficient indications for castration, "even when no anatomical changes are demonstrable," there would be no object in laying any stress upon the presence of oöphoritis; but the more conservative reader will rather believe, with Hegar and Winckel, that the gynæcologist should not venture upon such a radical step unless he can demonstrate to his own satisfaction the presence of ovarian disease. But, even then, as Olshausen himself admits, many symptoms, supposed to be due purely to organic changes in the ovary, may be due to extrinsic causes (peri-oöphoritis) or to intrinsic, as neuralgia. This brings us to the vital point of the whole matter—oöphorectomy, performed for the relief of actual, or supposed, ovarian trouble, as indicated by local pain, dysmenorrhœa, and reflex disturbances, is in many cases a *purely empirical measure.*

If we remove a diseased ovary from a young woman, leaving the other because it appears to be perfectly healthy, and one or two years later she informs us that she has precisely the same pain on the affected side, quite as severe before menstruation as it was previous to the operation, while the other ovary has also become the seat of pain, the natural inference is that she has not been greatly benefited by surgical interference. This picture is not a rare one, as every laparotomist who has made any attempt to follow up his patients must admit. Several hypotheses are offered to account for the persistence of the symptoms after the removal of the supposed cause. I incline to the belief that peri-oöphoritis and neuralgia combined are to be regarded as the frequent cause of supposed ovarian pain; the latter may be secondary to the former. How else can we explain, not only its persistence after the removal of diseased ovaries, but its decided amelioration as the result of local (especially electrical) treatment, while the condition of the glands themselves appears to be unaltered? Recovery from the operation is not recovery from the symptoms for which the operation was undertaken, and this is a truth that is beginning to force itself more and more upon the laparotomist. On the other hand, after a patient has been under observation and treatment for several months, and has grown no better, but rather worse, as shown by both her symptoms and her local condition, and after the risks and uncertainties of the operation have been frankly explained to her, it may properly be performed as a last resort. The surgeon will do well to strengthen his position by reminding the patient that the benefits may not be apparent for at least a year; well-authenticated cases of instantaneous relief after oöphorectomy are not so numerous as the reader would infer from the statements of ultra-enthusiastic operators.

Removal of both the tubes and ovaries is, of course, the operation now practised under the name oöphorectomy (salpingo-oöphorectomy, to use the correct, though ponderous, term), though in cases such as have been described here the tubes are often not only apparently, but actually, healthy. As performed for the express purpose of extirpating diseased tubes, it does not concern us now, except that it may be said that while the ovaries are nearly always more or less affected in cases of salpingitis, the reverse is not true, *i.e.*, chronic oöphoritis exists independently of salpingitis. With Battey's operation, as originally proposed, we are not concerned here, except so far as the nervous and mental phenomena (to relieve which Battey seeks to establish a premature menopause by removing the ovaries) are associated with, or depend upon, actual ovarian disease. Having lifted the ovary into the wound, there is no choice between removing it or letting it alone. If, at the operating-table, it is found to be extensively diseased, it is regarded as unsurgical to be content with puncturing the larger cysts, simply ligating the pedicle, or even excising the diseased portions of the gland and leaving the healthy part (as Schroeder did successfully in several instances, pregnancy ensuing in one case). The separation of peri-oöphoritic adhesions without removal of the ovary is of doubtful value. On the other hand, if an ovary is merely "suspicious," and shows only apparent evidences of disease, the corresponding tube being healthy, there is still time to give the patient the benefit of the doubt. It is extremely difficult to choose the right path, especially if the decision is left entirely with the surgeon; while the subsequent occurrence of pregnancy may cause him to be devoutly thankful that he spared the suspicious organ, on the other hand, the development of a large cyst may occasion feelings that are directly the reverse. A word should be added regarding some phenomena occasionally observed after the removal of the uterine appendages. In quite a respectable proportion of the cases the monthly flow does not cease for several months, or even for years, although no morbid condition of the uterus is present to account for the hæmorrhage. It is not necessary to resort to the theory of a possible third ovary, or of imperfect removal of one of the glands. As has been shown by careful observers, persistent metrostaxis is most common in patients in whom extensive adhesions were found at the time of the operation; it is not difficult, in view of our present knowledge regarding the separate identity of ovulation and menstruation, to explain the monthly flow as due to the pelvic congestion induced by the perimetritis. Nor is this all. Even after the lapse of two or three years the patient still suffers every month from cerebral congestion, profuse perspiration, pelvic and reflex neuralgic pains, and even psychical disturbances such as formerly attended the menstrual nisus. Vicarious hæmorrhages, especially epistaxis, are not uncommon. It is hardly necessary to remind the reader that no intelligent observer now entertains the idea that a woman is "unsexed" by the removal of her diseased tubes and ovaries, since, as Dr. Goodell aptly says, "her instincts and affections remain the same, her sexual organs continue to be excitable, her breasts do not wither up, and she is no less a mother or a wife." The question that is still *sub judice* is this: *Can we offer the sufferer from ovarian disease a prospect of relief by laparotomy sufficiently certain and permanent to compensate her for the risks which she must take?*

II. Tumors of the Ovary.—These are divided into solid and cystic, the latter being by far the more common.

1. *Solid Tumors of the Ovary.*—These growths are characterized anatomically as benign or malignant, although

clinically it is not always possible to insist upon this distinction. Under the former are included pure fibromata, under the latter carcinoma and sarcoma. Fibro-adenoma, pure myxoma, enchondroma, and tuberculous disease of the ovary are so rare that we need only make a passing allusion to them.

A. *Fibroma.*—I cannot agree with most writers on ovarian pathology that fibroid tumors are so exceedingly rare as they represent, since I have an opportunity to examine two or three undoubted specimens every year, and see reports of many more in current literature. There are now a large number of cases on record. Moreover, I differ from Olshausen and others, who affirm that such growths are always the results of hyperplasia of the stroma, resulting from former inflammatory processes, and are never independent morbid growths. There are doubtless many specimens of ovaries, enlarged to the size of a hen's egg or an orange, which, from their gross and microscopic appearance, may fairly be regarded as examples of excessive fibroid hypertrophy in consequence of preceding oophoritis, but these are to be distinguished from the tumors under consideration, just as a hyperplastic is to be differentiated from a fibroid uterus. Some careful observers deny the existence of true ovarian fibromata, alleging that the tumors thus described are either detached subperitoneal uterine fibroids, or fibrous growths of the tube or broad ligament. Others affirm that all supposed fibroids of the ovary are really spindle-celled sarcomata.

Etiology.—While the smaller tumors show evidences of growth by simple hyperplasia of the stroma, the larger ones closely resemble uterine fibroids, in the obscurity of their etiology as well as in their structure. There is, as a rule, absolutely nothing to account for their presence. They have been found as separate nodules growing from the stroma or outer surface of the ovary, the gland itself being normal. A few cases are on record in which they developed from the *corpus luteum*.

Gross Anatomy.—An ovarian fibroid is usually of small size (weighing in the neighborhood of two pounds), although I have seen a specimen weighing upwards of twenty pounds. It closely resembles a subperitoneal fibroid, having a smooth, shining exterior, and is often nodular or divided into several lobes. It may be of almost stony hardness, or may undergo every variety of degeneration common to fibroids, until it becomes a true fibro-cyst, the latter condition being the result of geodic softening (*fibroma lymphangiectodes*). Ovarian fibro-cysts may attain such a size as to fill the abdomen. Spiegelberg removed one that weighed sixty pounds.

Interstitial hæmorrhage, fatty and calcareous degeneration, etc., are not uncommon; a transition to spindle-celled sarcoma is possible, but never to carcinoma. These tumors are generally unilateral, especially when of large size, and have precisely the same relations to the tube and broad ligament as cystomata—an indisputable proof of their ovarian origin. Contrary to Goodell's experience, I have found that the pedicle is usually long and slender, so that the tumor floats freely in the abdominal cavity; adhesions are rare, unless the growth has reached a large size, when it may become attached to the anterior parietal peritoneum. In consequence of the mobility of these tumors and the length of the pedicle, torsion of the latter not infrequently occurs.

Ascites is a common complication of ovarian fibroids, and may awaken suspicions regarding the possible malignancy of the growth. The ascites is sometimes explicable by the venous obstruction due to the direct pressure of the mass, or possibly to long-continued irritation of the peritoneum; more often the cause is unknown.

Minute Anatomy.—The smaller tumors appear to consist wholly of dense fibrous tissue; in the larger ones occasional smooth muscle-fibres are found, justifying the name myo-fibroma. "Geodes" are numerous in the larger growths, where their development can be traced from the commencing dilatation of a lymph-space, in consequence of local stasis, up to cavities containing half a pint of clear serous fluid, coagulating spontaneously on exposure to the air. The various microscopical appearances are identical with those observed in studying sections of uterine fibroids and fibro-cysts, except that a tendency to sarcomatous degeneration is more frequently noted.

Clinical History.—The presence of the tumor may be entirely unsuspected during life; in fact, small fibroids possess no clinical significance, unless they result from chronic oöphoritis, the symptoms of which have been detailed. They are found most frequently in young women (below the age of forty), and rarely attract attention, except by their mechanical pressure, until they have risen out of the pelvis. They cause no pain or deterioration of the general health, and when small are as innocuous as sub-peritoneal fibroids. Cases are on record, however, in which they have given rise to serious dystocia. Being of slow growth, the patient can rarely recall the precise time when her attention was first directed to the tumor by dragging sensations in the lower part of the abdomen, enlargement of the same, and a feeling as if there was some foreign body in her belly which shifted its position as she turned over in bed. Ascites may be the only symptom for the relief of which she consults a physician. The large tumors, especially the fibro-cystic variety, give rise to the usual disturbances of such growths, but not to any severe pain. These will be mentioned in describing the complications of cystomata. The tendency of these tumors to become fibro-sarcomatous always causes apprehension.

Diagnosis.—If the tumor has been under observation for some time and is of small size, its ovarian origin may generally be determined. It is often impossible to distinguish it from a sub-peritoneal uterine fibroid with a long pedicle. Small semi-solid dermoid or multilocular cysts may be mistaken for fibromata. The very slow growth and peculiar, hard, nodular feel of the latter is quite characteristic. If the tumor can be felt distinctly through the vaginal vault (as in a case of probable double ovarian fibroid which I have now under observation) the differential diagnosis is not so difficult. If it is so large that its unilateral situation is no longer apparent, to make a diagnosis between it and a uterine-fibroid or fibro-cyst is clearly impossible. The question of malignancy always arises in these cases, especially if ascites is present. The slow development of the tumor, its mobility, smooth surface, and the fact that it is unilateral, the absence of pain, and the general condition of the patient, should point to its true character.

Prognosis.—This is invariably good, since these tumors grow slowly, often undergo atrophy after the menopause, and rarely cause peritonitis or become the seat of suppuration. The ascites which sometimes complicates them is entirely cured by the removal of the tumor, an operation which is rendered quite easy by the almost invariable absence of adhesions.

Treatment.—Ovariotomy is the only resort, the results of the operation in this class of cases being excellent. As in the case of all solid tumors, the abdominal incision must be longer than that made in removing ordinary cysts. The possibility that a solid tumor may be, or may become, sarcomatous, always renders an operation advisable.

B. *Sarcoma.*—This develops primarily in the ovary. Olshausen says that the spindle-celled variety is most common. The few specimens which I have examined have been of the transitional round-celled type (*sarcoma carcinomatodes*). Between the two there exists a wide difference as regards malignancy, since the former (fitly termed fibro-sarcoma) is closely allied to fibroma, while the latter approaches closely in its structure and dangerous character to medullary carcinoma.

(*a*) *Spindle-celled Sarcoma.* Etiology.—Fibro-sarcoma develops, like fibroma, from the stroma, the original change in both instances suggesting simple hyperplasia; but, while the benign growth is comparatively poor in vessels, the vascular supply of the former is excessive. The ultimate cause of the malignant formation is of course unknown, but it seems to be related to the period of development, because sarcoma of the ovary is most often found

in early life, not infrequently in childhood. A form of adeno-sarcoma described by Leopold develops from the Graafian vesicles. The origin of the rapidly growing sarcomata of the mixed type is not clear; it is doubtless epithelial as well as stromal.

Gross Anatomy.—Malignant tumors of the ovary are frequently bilateral. The fibro-sarcomata are usually of moderate size (one or two pounds), of a smooth exterior, reddish-white in color, and of firm consistence. They may reach the size of a child's head, while sarcomatous nodules are seen on their outer surface. Small cysts sometimes project above their surface. They closely resemble fibromata, but are usually of less firm consistence. On section their cut surfaces appear softer and much more vascular, often resembling raw meat, especially when the tumor is of the mixed spindle- and round-celled variety. Rapid growth, inflammation, and degeneration are characteristics of these formations, as shown by the hyperæmic and œdematous appearance of their cut surfaces, the fatty and necrotic foci, and the numerous cysts containing a reddish, gelatinous fluid.

Minute Anatomy.—It is not necessary to dwell upon the well-known microscopical anatomy of these tumors, except to reiterate that they are characterized by their vascularity and tendency to retrograde metamorphosis, the latter being readily explained by reference to the venous thrombosis observed under the microscope. The occurrence of metastatic deposits in distant organs depends upon the involvement of the blood-vessels in the morbid process. Retrograde changes are, of course, less marked in fibro-sarcomata. It should be noted that myxo-sarcoma often occurs in the ovary.

Clinical History.—It may be said, in general, that fibro-sarcoma of the ovary may be attended by few, if any, graver symptoms than those produced by benign solid growths. These growths have little tendency to form metastatic deposits, and may increase very slowly for years (ten years in one case) until they reach an immense size (sixty or eighty pounds), the general health not being affected, after which they undergo cystic degeneration or assume a more malignant character. Pain is often absent or insignificant, and moderate ascites is frequently the only symptom that attracts attention, aside from the irregular menstruation or amenorrhœa, which would naturally attend disease of both ovaries. In short, the natural history of fibro-sarcoma is essentially that of fibroma, and the diagnosis is commonly uncertain until the specimen is in the hands of the pathologist.

As the cellular element predominates in the growth, the condition becomes more grave; still, as Olshausen says, "on the whole, sarcomata of the ovary are relatively of slight malignity, seldom form metastases, and are not so very often double. Their malignant character is shown more by their striking influence upon the general health." I have found the most malignant type of sarcoma of the ovaries and peritoneum in a young woman who appeared to be in robust health, and was entirely unconscious of her condition. I have also discovered in the dead-house unsuspected metastases in the intestinal canal. The soft, round-celled variety grows rapidly, is usually bilateral, and terminates fatally in a few months, the patient generally dying from exhaustion. Ascites, peritonitis, and pulmonary complications hasten the end. The pain may be of the characteristic sharp, lancinating variety, especially if subacute peritonitis is present, while disturbances of the pelvic organs are indicated by uterine hæmorrhage; rectal and vesical troubles are not uncommon.

Diagnosis.—As before stated, a differential diagnosis between fibroma and spindle-celled sarcoma is practically impossible; a solid ovarian tumor of slow growth is more apt to be of the latter character. Between round-celled sarcoma and medullary carcinoma it is often impossible to distinguish, nor is the distinction of any importance clinically. The youth of the patient, the more gradual development of cachexia, and the moderate ascites, as well as the less rapid extension of the disease to the abdominal viscera, speak in favor of sarcoma. Peritonitis is more common in cases of cancer, and on examination the pelvic organs are found to be fused into a solid, immovable mass; the pain is also apt to be more severe. A large cysto-sarcoma may be mistaken for a thick-walled cystoma, for a cyst that has undergone secondary malignant degeneration, or for an ovarian or uterine fibro-cyst. Similar symptoms (pain, cachexia, ascites, etc.) may be present in each case. An exploratory puncture may throw light on the diagnosis, the contents of a cysto-sarcoma being a peculiar bloody, gelatinous fluid (often containing characteristic cell-masses) which contains mucin and paralbumin and coagulates spontaneously.

Prognosis.—In fibro-sarcoma the prognosis is good, removal of the tumor being nearly always followed by complete recovery. In growths of the round-celled variety it is not encouraging, on account of their influence on the general health, the tendency to metastasis and other complications, and the danger from operative interference—death from shock, hæmorrhage, or peritonitis, being a frequent result of attempts at removal.

Treatment.—If the tumor is freely movable, and the patient's general condition allows it, ovariotomy is clearly indicated; since, if the growth is thoroughly removed before secondary deposits are formed, there is comparatively little danger of recurrence, and a radical cure may be expected. The question of the expediency of laparotomy in cases of extensive malignant disease, with well-marked cachexia, will be discussed in the following section.

C. *Carcinoma.*—This may be primary or secondary, and may be of the medullary, scirrhous, or colloid variety, the medullary being by far the most frequent. Carcinomatous degeneration of cystomata will be more properly considered elsewhere. Unnecessary confusion has arisen from the loose use of the term "papilloma," some writers regarding all proliferating papillomatous cysts as malignant. For this reason I prefer to omit them from the present section, although many of these are really solid tumors of the adeno-carcinomatous and adeno-sarcomatous type. Colloid cancer of the ovary is a transitional form, which will be described under colloid cysts. Scirrhous cancer of the ovary is too rare to call for separate mention in a brief *résumé* like the present.

Etiology.—Medullary carcinoma of the ovary may be secondary to cancer of the pelvic organs or peritoneum, although it is sometimes extremely difficult to trace the sequence. These cases possess a pathological, rather than a surgical, interest, and will not be considered. Primary cancer of the ovary should be clearly distinguished from secondary cancerous degeneration of a pre-existing cyst, since the prognosis, as well as the treatment, in the two cases is essentially different. The ultimate cause of primary malignant disease is unknown. The patients are frequently under thirty years of age, a peculiarity as regards cancer of the ovary, in comparison with cancer of other organs, which seems to point to the period of the greatest sexual activity as the one most favorable to the development of the disease. Frequent pregnancies do not appear to exert any special influence. Sexual excess has been noted as a possible etiological factor. The growth takes its origin from the epithelial elements of the ovary, principally those of the ovisacs, malignancy being, as Tait has expressed it, "a reversion to the fœtal type." That the process is at first confined to a few vesicles is shown clinically, as well as anatomically, by the fact that patients with cancer of both ovaries have ovulated and become pregnant.

Gross Anatomy.—In the early stage a cancerous ovary appears somewhat enlarged, of an irregular, nodular shape, a dead-white color, and of softer consistence than normal. At this time the tumor may be perfectly movable, and may resemble closely an ordinary hypertrophied ovary. I have seen a carcinoma as large as a man's head that closely resembled a uterine fibroid, even on section. It was removed from a young woman, aged twenty-two, who had complained of few symptoms except occasional dragging sensations in the stomach. When the disease is advanced, we observe, on looking into the pelvis from above, a diffuse, irregular mass involving both ovaries, often the rectum and uterus, and frequently also coils of

small intestine, and distributed over the peritoneum in the shape of smooth nodules or papillary excrescences. The consistence of the growths varies from that of a soft fibroid to the cheesy, diffluent condition which characterizes malignant diseases of the liver.

Minute Anatomy.—The structure of medullary carcinoma is well known, and does not require a separate description as it is found in the ovary. These growths are prone to become the seat of inflammatory and degenerative processes which obscure their original appearance. We seldom have an opportunity to observe the disease in its inception before the stroma and ovisacs have been entirely destroyed, and when the alveolar structure of the growth is clearly marked, by reason of the scattered collections of epitheloid cells. The frequent occurrence in the ovary of the mixed type, "alveolar sarcoma," or sarcoma carcinomatodes, has been mentioned. It is worth noting that, aside from rapid growth and tendency to degeneration and extension as clinical evidences of malignancy, the finding of the "budding" or "sprouting" cells at the periphery of a cancerous ovary testifies to its dangerous character. Some of the circumscribed tumors appear to be almost encapsulated, as contrasted with the soft, diffuse growths. Microscopically the difference between a cysto-carcinoma and a carcinomatous cystoma is, broadly speaking, this: In the former we find an irregular cavity, plainly the result of degenerative changes (fatty, necrotic, etc.), and situated in the midst of a homogeneous cancerous tissue; while careful examination of sections of the wall of an ovarian cyst that has undergone secondary carcinomatous degeneration will nearly always reveal evidences of the original cyst-wall, with its usual layers.

Clinical History.—The symptoms of cancer of the ovary may be entirely negative, or, on the other hand, while there is no doubt regarding the existence of malignant disease, it may involve the pelvic and abdominal viscera so extensively that its connection with the ovaries is obscured. Pain of a peculiar, sharp, darting character is generally regarded as characteristic of cancerous growths. But it is a singular fact that this symptom is often wanting in extensive malignant disease of the pelvic organs, which, from their rich nerve-supply, we might suppose would be most profoundly affected. I have repeatedly seen cancer of the ovary revealed by laparotomy in cases where the pain had not been any more severe than that which attends chronic cellulitis. Again, pain of an apparently suspicious character may be produced by so many morbid conditions within the pelvis that it is not to be regarded as a trustworthy indication of malignancy. The pain, when it is present, makes its appearance gradually, the patient having an occasional twinge or stab in the groin, which sometimes extends down the thigh. As the growth becomes more diffuse and begins to break down and extend to the peritoneum, that membrane becomes the seat of a subacute inflammation, in consequence of which the pelvic organs are fixed just as if they had been embedded in liquid plaster which had subsequently hardened. The patient may then suffer acutely, locomotion being impossible. Menstrual disturbances appear—first, menorrhagia, then irregularity of the flow, and eventually, as the ovaries are completely destroyed, complete amenorrhœa. The effect of the condition upon the uterus is the same as that produced by ordinary pelvic peritonitis—*i.e.*, it causes congestion and a tendency to hæmorrhages. Vesical irritation is a distressing symptom, and constipation and painful defecation result from mechanical obstruction. In aggravated cases coils of small intestine are imprisoned at the bottom of Douglas's pouch, giving rise to frequent violent, colicky pains by reason of the resistance offered to the peristaltic movements. Ascites is justly regarded as an important symptom in connection with malignant disease. The important point to note is that the dropsy develops *early* and *rapidly*, its time of appearance not being governed by the size of the tumor, since it is due rather to irritation of the peritoneum than to direct pressure on the vena cava inferior. If the fluid is removed by tapping, it quickly returns. Sometimes œdema of one or both legs is observed, in consequence of direct pressure of the growth on the iliac vessel.

The "cancerous cachexia" is often alluded to as pathognomonic. This is quite as often absent as present, some of the women being young and blooming. On the other hand, the face of a patient with extensive secondary deposits on the peritoneum and intestines does sometimes present a peculiar hue and a drawn expression which are certainly striking. This is best marked in women above forty, and is accompanied by emaciation and rapid decline of the vital powers.

Diagnosis.—In the case of young patients who complain of only moderate pain, appear in good health, and have little, if any, ascites, the physician may naturally fail to discover the true condition. When the tumor is small, and is buried in a mass of adhesions, it may be mistaken for a benign growth, for an enlargement of the tube or ovary, or for chronic peritonitis. The diagnosis may be equally uncertain after the tumor has risen out of the pelvis, provided that it is painless, movable, and not associated with ascites and constitutional disturbance. Age, as has been stated, is not a reliable criterion; but, negatively, a rapidly growing tumor in a woman over forty should awaken grave suspicion.

Ascites (with or without œdema of the legs) developing rapidly in a patient, who is found by careful examination to be free from cardiac, renal, or hepatic disease, is a significant symptom, especially if it is associated with severe lancinating pains in the groins and a general cachexia or decline of the health for which no reason can be assigned. Evidences of subacute peritonitis, as presented by great tenderness over the lower part of the abdomen and elevation of the pulse and temperature, possess no little significance in connection with the other symptoms.

Since the pain is located in the pelvis, we naturally make a vaginal examination. The uterus is found high up—so that the cervix appears as if it were drawn into the fornix—and is immovable, while the entire vaginal vault presents a peculiar, hard, board-like feel. There is usually so much tenderness, on account of the general inflammation, that no definite information can be gained; in very favorable cases an irregular nodular growth, perfectly immovable, can be obscurely felt through each lateral fornix. If there is no ascitic fluid, and the patient is not too sensitive (or is under ether), the tumors can be mapped out by the bimanual examination, while their peculiar, knobbed exterior is recognizable. If the ascites prevents a thorough examination the fluid should be removed by an aspirator, when a flood of light is often thrown upon an obscure diagnosis. It is so important for the physician to obtain all the information possible, regarding the nature of the disease and its precise extent, that he should employ every diagnostic aid at his command. I have on several occasions seen extensive malignant disease of the abdominal viscera completely masked by ascitic fluid, the removal of a few ounces of which cleared up the diagnosis, and saved the patient from a proposed laparotomy which would have been worse than useless. In this connection I cannot refrain from expressing my disapproval of a hasty resort to explorative laparotomy in cases of ascites where the presence of malignant disease is strongly suspected, and all the symptoms point to the existence of extensive infiltration and subacute peritonitis such as would render a radical operation impossible. I have seen this exploration undertaken on the person of a woman whose abdominal, and even thoracic, viscera were riddled with secondary growths; she, of course, did not survive. It seems much more rational to tap a woman in whom we suspect malignant disease, to make repeated examinations, and to keep her under observation for some time, than to open her abdomen at once in order to satisfy our curiosity. The result of explorative incision in these cases is fatal in a large proportion of cases, the patient dying of shock or exhaustion. This opinion, it should be stated, is opposed to that of weighty authorities, yet it is supported by the facts. Foulis and Thornton have called attention to the diagnostic value of the so-called "sprout-

ing cell-groups" found in cancerous ascitic fluid. These are clusters of large epithelial cells, containing vacuoles of different sizes; in my experience, when found in large numbers, they point strongly to the existence of a proliferating malignant growth (carcinoma, sarcoma, or papilloma) which has extended to the peritoneum. The rapid re-accumulation of ascitic fluid after aspiration points to a probable cancerous origin.

Prognosis.—This is invariably bad. While some patients may live for years, exhibiting alternate remissions and exacerbations, others succumb in a few months from pure exhaustion, peritonitis, or secondary complications induced by metastatic deposits in the thorax or abdomen. The retro-peritoneal glands and peritoneum are early involved, next in order the intestines, omentum, stomach, and liver; but, strange to say, the other pelvic organs (uterus and bladder) frequently escape. Even when the tumors are movable, so that they can be completely extirpated, we can never be sure either that metastatic deposits do not already exist or that there will not be a recurrence. Olshausen has called attention to the difference between ovarian sarcoma and carcinoma in this respect; spindle-celled sarcoma rarely recurs after complete removal.

Treatment.—Many malignant tumors are not recognized as such until after their removal. When the growth is not too firmly adherent it is justifiable to extirpate it, if no secondary nodules are discovered on the peritoneum, since the patient's life is prolonged and there is always a possibility that the disease may not recur. To tear out by main force a soft, vascular, cancerous tumor, firmly adherent to the pelvic and abdominal viscera, with imminent risk of having the patient die on the table from shock or hæmorrhage, is unsurgical, not to say inhumane. The resection of the intestines, bladder, etc., with the tumor is a procedure which we may leave to our German *confrères*.

We may briefly summarize the treatment of carcinoma ovarii by saying that when we are reasonably sure of the presence of advanced malignant disease we should be content with trying to make the patient as comfortable as possible by administering opium freely, withdrawing the ascitic fluid when necessary, and building up the general strength. Ovariotomy in cases of adherent solid malignant tumors is always dangerous and the result is questionable; nevertheless it is now generally held that the patient should be given the benefit of the doubt. A considerable number of patients do not survive the operation.

2. *Cystic Tumors of the Ovary.*—A. *Dermoid Cysts.* They form between three and four per cent. of ovarian cysts. These curious growths are congenital unilocular cysts, the walls of which present a more or less perfect epidermal structure, while their interior is filled with caseous material, in which are often found hair, teeth, bone, etc. These cysts are always simple, are usually single, and seldom reach a size larger than a man's head. I have examined specimens of multilocular colloid cystomata, a few loculi of which presented a well-marked dermoid structure, and contained hair and teeth; as a rule these tumors are homogeneous.

Etiology.—Dermoid cysts are not peculiar to the ovary, being found in the mouth and pharynx, in the testicle, and in other localities, but their origin in each organ is equally obscure. It is impossible to enter into a minute discussion of the different theories; suffice it to say that there are two principal ones, some authorities believing that there is an inclusion of abnormal structures in the fœtal ovary, while others affirm that these curious tumors are caused by excessive growth of the ovarian elements. Others, drawing upon their scientific imagination, advance the theory of "fœtus in fœtu," or inclusion of an imperfect within a perfect one, or of "hypererchesis"—an inherent power possessed by the ovum of forming certain rudimentary tissues without the assistance of the male germ. In the absence of any better explanation the reader may accept Elsner's statement, that "dermoids occur externally and internally in places where the epiblast dips down to meet the hypoblast, and where, by processes of grooved involution, new bodies are formed, such being, first in order, the testicle and ovary, and that they are therefore all, without exception, embryonal in their first structure." Dermoid cysts are frequently found in young children, and their development seems to belong to the period of puberty and greatest sexual activity, about two-thirds of the growths occurring in women under thirty. It is probable that a large proportion of them exist at birth and grow very slowly until puberty, when they share in the development of the pelvic organs and enlarge rapidly. It has been shown that the presence of dermoids seems to retard the time of puberty.

Gross Anatomy.—A typical dermoid cyst is commonly intra-pelvic, being about the size of a large orange or of a fœtal head at term, and is lodged in Douglas's pouch. It has a smooth exterior, a wall of variable thickness, and a consistence differing according to the degree of fluidity of its contents. The relations of the tumor to the tube and broad ligament are not always clear, on account of the frequent occurrence of inflammatory adhesions, which these cysts are extremely liable to contract. On section it will be found that the wall is thick, almost cartilaginous in some places, and quite thin in others. It has not the smooth, epithelial lining of a simple cystoma, but presents in many places a rugose appearance, resembling that of the hands after being dipped for some time in hot water. A cyst which has become the seat of suppuration and necrosis may lose its original appearance, so as to resemble the sac of a pelvic abscess, while its contents are transformed into fetid pus. Long, coarse hairs are frequently seen growing from this epidermal lining. The cyst-contents vary from a thick, oily fluid in which float cheesy lumps, to a solid mass similar to that found in an ordinary wen. This is partly fluid at the temperature of the body, but rapidly hardens. Large masses, or coils, of blond (rarely dark) hair are often found in these cysts; the hairs are sometimes several inches long, and may form regular locks. Bone and teeth, when present, are usually partly embedded in the epidermal layer, or they may be contained in diverticula; the bits of bone are mostly of irregular shape, and contain but little cancellous tissue. The teeth are separate, or attached to an alveolar process; they are usually rudimentary, although they may closely resemble normal teeth. They may be present in enormous numbers (three hundred were found in a single cyst), and are found in about one-fifth of the cases. Smooth muscle-fibres, and even nervous substance, have been found in dermoid cysts. Mixed dermoid and colloid, and dermoid and sarcomatous tumors have been described. Dermoids rarely show a tendency to form metastatic deposits.

Minute Anatomy.—Sections through the thicker portions of the wall show the ordinary structure of epidermis, including the epithelial layer and corium, the latter sometimes including papillæ. Hairs (with the arrectores pili), sebaceous- and sometimes sweat-glands, are present as in sections of the skin. The cyst-contents under the microscope are seen to consist of cholesterin, oil-globules, fatty, degenerated epithelial cells, and amorphous matter.

Clinical History.—Since the tumors are of slow growth and remain latent until after puberty, they may give rise to no symptoms whatever. On the other hand, from their tendency to become inflamed and to suppurate, dermoids are the most dangerous of the non-malignant ovarian cysts. As they are commonly intra-pelvic and become adherent to neighboring organs, especially to the posterior surface of the uterus, they may cause displacements and pressure-symptoms. Rectal and vesical troubles are common. Pain, out of proportion to the size of the growth, is frequently present, due probably to subacute peritonitis. Evidences of local inflammation, elevation of temperature, hectic, and other signs of suppuration in a patient with a small pelvic tumor of slow growth should always awaken suspicion of threatening perforation from a dermoid cyst; the diagnosis will be verified if there is a sudden discharge of the characteristic caseous matter (containing tufts of hair) from the rec-

tum, vagina, or rarely from the bladder. Symptoms of peritonitis quickly follow rupture into the peritoneal cavity, death being the almost inevitable ending.

Diagnosis.—A small, thick-walled tumor, of very slow growth, situated in Douglass's pouch and fixed there by adhesions, occurring in a young woman, is likely to be a dermoid cyst, although the diagnosis is never certain until the abdomen is opened, and the contents of the cyst are removed by puncture or are evacuated spontaneously. The conditions most likely to be mistaken for dermoid cyst are small ovarian and parovarian cystomata, solid tumors of the ovary (also subperitoneal fibroid of the uterus), pelvic abscess, enlargement of the tube, and possibly tubal pregnancy. Unless the case has been under observation for some time, a positive differential diagnosis can seldom be made, unless we resort to explorative puncture with a fine hypodermic needle (through the vaginal vault), or suppuration occurs and the contents of the cyst are discharged. Puncture is not entirely devoid of danger, and the fluid is usually too thick to flow through a small cannula; the surgeon should be prepared to operate if this procedure is followed by signs of suppuration or peritonitis. All the signs described as characteristic of dermoid growths—location, slow growth, size, absence of distinct fluctuation, etc.—are present in most of the conditions above mentioned. Rarely bones or teeth may be felt on vaginal examination.

Prognosis.—These cysts being intra-pelvic, and generally adherent, may cause dystocia during labor; moreover, they are apt to suppurate in consequence of the injury to which they are exposed at this time. They rarely attain a sufficient size either to cause disturbance of the abdominal or thoracic viscera, or to exhaust the general health. Localized peritonitis is a common complication, and the inflammation may become general and fatal. Suppuration and perforation of the cyst may result fatally from the drain upon the vital powers, or from peritonitis. Fistulous openings in the abdominal wall sometimes result and are slow to heal; if the cyst communicates with the rectum or bladder (especially with the latter), the subsequent history of the case is similar to that of a pelvic abscess under the same conditions. Septicæmia is a real danger in these cases. The prognosis of laparotomy is somewhat doubtful, because of the frequent presence of firm adhesions.

Treatment.—The knife alone offers any prospect of cure, aspiration being contra-indicated. It may be stated briefly, that a dermoid cyst should be either incised freely and drained, or removed, or let alone. Aspiration of a portion of the contents is certain to be followed by suppuration, necessitating a subsequent incision—provided that the sac does not rupture spontaneously. Moreover, the fluid is seldom or never sufficiently thin to escape through even the largest-sized needle. The needle may, of course, be introduced as a guide, and a narrow-bladed knife may be passed in by the side of it—in short, the *modus operandi* is that followed in opening pelvic abscesses, viz., a free incision, followed by the introduction of a good-sized drainage-tube, through which antiseptic irrigation can be practised. This method of treatment is, of course, only suitable to cases in which the cyst is of moderate size, is firmly adherent, and is situated so low in the pelvis that it is directly accessible through the posterior fornix. Symptoms of suppuration indicate the necessity of immediate interference. The complete removal of the cyst is the desideratum, and this is often effected before its true character is recognized. The management of complications will be described elsewhere.

The operation is generally rendered difficult by the existence of general adhesions, out of which the tumor should be shelled entire, since it is desirable to avoid puncturing it if possible. It will usually be necessary to make a longer abdominal incision than is necessary for simple ovarian cysts. If the trocar is introduced and the characteristic oily fluid begins to flow, the surgeon should exercise more than usual care to prevent it from entering the peritoneal cavity; some operators withdraw the cannula as soon as they recognize the character of the cyst, close the puncture with the finger or with a stitch, and enlarge the abdominal wound so as to lift out the entire mass. If the cyst is firmly adherent, we are advised by most writers to follow the usual course in such cases, viz., to open, empty, and wash out the sac, to introduce a drainage-tube into it, and, finally, to stitch it into the abdominal wound. Much judgment is required in deciding upon the proper management of this complication. If the cyst is of moderate size and is accessible through the vagina, I should prefer to close the abdominal wound and to incise and drain the sac in the manner previously described, rather than to draw it up forcibly out of the pelvis and secure it as recommended.

The treatment of dermoid cysts with fistulous openings into one of the hollow viscera is unsatisfactory; the ordinary surgical rule should be followed of making a free incision, and endeavoring to promote the collapse of the sac by granulation and adhesion of its walls. Extirpation is sometimes possible, especially if the tumor is abdominal.

B. *Ovarian Cysts Proper.* Under the general term "ovarian cysts" are included a number of growths which, anatomically, cannot properly be grouped together. Clinically, surgeons have fallen into the habit of regarding as cysts tumors which are nearly, or entirely, of a solid character, while pathologically these may exhibit all degrees of malignancy. But in a practical article like the present it would be pedantic to insist upon a strict anatomical classification. We shall divide cystomata broadly into the simple and proliferating varieties, considering subsequently variations from the common type, both benign and malignant.

Etiology.—The causes are obscure, yet statistical researches have led to the establishment of certain general facts which may be stated briefly as follows: Although no age is exempt ovarian cysts have been found in the fœtus, and cases of ovariotomy in girls under puberty are recorded), they are most common during the period of greatest sexual activity, being infrequent after fifty. The unmarried and sterile are far more liable to be affected than are those in whom the reproductive organs fulfil their proper functions; the inference is that uninterrupted menstrual congestion favors the development of morbid growths, as well as diseases, of the ovary. It has been affirmed that pregnancy is a direct etiological factor in the development of ovarian cysts; it is probably more correct to say that pre-existing cysts grow rapidly under the influence of this condition, as we shall see later.

Heredity has been urged as a possible cause, but if this influence exists at all, it is probably confined to cases of malignant growth. The reason for the greater frequency of cysts of the left ovary cannot be established, as in oöphoritis. Scanzoni has sought to trace a direct causal relation between amenorrhœa and chlorosis and cystic growths, but his statistics are scanty and imperfect. There is no evidence that a woman's general condition has anything to do with the development of these tumors. It is interesting to note that while cystic degeneration of both ovaries is quite common, double cysts occur in only eight or ten per cent. of the whole number of cases, and the majority of these are either clinically or anatomically malignant.

Mode of Formation.—The ingenious illustration employed by a writer on diseases of the ovaries, of a number of soap-bubbles coalescing through the bursting of their thin walls, so as to form a single sphere, expresses graphically a simple and attractive theory of the formation of ovarian cysts—by the general dilatation and fusion of contiguous Graafian vesicles. By this theory doubtless not a few laparotomists justify the removal of slightly diseased ovaries, on the ground that the patient is thus saved from the inevitable danger of developing one or more large cysts. Attention has already been called to the infrequency of double cystomata as compared with the existence of cystic degeneration of both ovaries. Shall we accept the statement that "ovarian cystoma is the result of follicular dropsy only," or seek for some additional explanation of the histogenesis of

these protean growths? It will certainly be more sensible to examine all the evidence before coming to a definite conclusion. It must occur to the most superficial observer that, since there are so many variations in their appearance, structure, and mode of growth, it may be possible that the origin of all cannot be explained in the same simple manner. Moreover, it is not to be supposed that the subject has yet been exhausted; indeed, careful pathologists affirm that we have only touched upon it as yet, so that dogmatic statements are hardly warranted. Waiving the question as to whether a purely unilocular ovarian cyst can exist, let us consider first the probable origin of simple cysts, or those which evidently result from hydrops ovarii. Although these seldom attain a large size (they form only one per cent. of the tumors removed by laparotomy, according to Olshausen), they have been carefully studied, and there is no doubt as to their origin. Finding in a given specimen, in addition to a large cyst which shows in its interior traces of having been formed by the coalescence of several smaller ones, smaller cysts of different sizes, the smallest being dilated vesicles still containing ova, the above inference is legitimate. This is supported by further anatomical evidence, as the structure of the wall is the same in the largest cyst as in the dilated ovisac. But some writers go still further, and affirm that cystic adenomata and papillomata result from proliferation of the single layer of epithelium lining these simple cysts.

It is also true that the degeneration of undeveloped ovisacs and even of corpora lutea forms the starting-point of simple cysts. Several theories have been suggested to account for the formation of proliferous cysts, the principal one being that of Pflüger, who advanced the idea (supported by Waldeyer) that they take their origin from the germinal epithelium which penetrates into the stroma of the fœtal ovary in the form of tubular ingrowths from the peripheral layer of cells; these ingrowths are subsequently separated from the surface epithelium and form isolated cell-collections in the stroma, which later develop into Graafian vesicles. Cysts are then formed, according to this theory, by the degeneration of fœtal, rather than of mature, ovisacs, or in other words, germinal epithelial masses that would normally form Graafian vesicles, develop abnormally to form cysts. De Sinéty and Malassez have modified this theory by substituting for "Pflüger's ducts" certain "epithelial tubes," regarded by them as undeveloped Pflüger's ducts. Nöggerath has further demonstrated the probable origin of cysts from diseased blood-vessels, which, he holds, are the structures which others have mistaken for the ducts. All agree that the stroma takes little, if any, part in these changes, which are essentially of epithelial origin. The well-known tendency of fœtal epithelium to proliferate explains the luxuriant growth of the adenomatous masses, which sometimes fill the interior of the cyst. Some have affirmed that the epithelial tubes may form and develop into cysts in the adult, as well as in the fœtal, ovary. On the other hand, those who assert that the mature ovisac is the origin of the cyst, explain this most plausibly by saying that after the destruction of its ovum, the epithelium of the vesicle reverts to the fœtal type and thus acquires the same proliferating tendency as the fœtal tube. Space does not allow a further discussion of this interesting question, but, until we possess more evidence in favor of the common origin of all varieties of cyst from the dilated vesicle, on account of the dissimilarity that exists between the epithelium of the latter and that of a proliferous cyst, it seems wiser to accept provisionally the idea of fœtal formation. The investigations of Marchand and Flaischlen are in accord with this view, since they show (as I have noted in one beautiful specimen) that papillomata instead of being growths *sui generis*, also originate in the germinal epithelium, which in this case has assumed an unusual proliferating, or malignant, tendency. Recent investigations point also to the probable origin of these growths from that portion of the parovarium which enters the hilum of the ovary, thus proving that parovarian cysts are not always as innocent as has been supposed. The fluid within the cysts, variable as it is in character and appearance, is formed by degeneration of the epithelial cells. Papillomata secrete this fluid very rapidly, especially when they are not confined within the interior of a cyst, but spring from their exterior; hence the occurrence of ascites with papilloma, especially when it has invaded the peritoneum. Combinations of adenoma and papilloma are not uncommon, and the tendency of such cysts to become malignant will readily be understood by reference to the peculiar character of the epithelium.

Gross Anatomy.—Simple cysts arising from dilated ovisacs seldom reach the size of a man's head; indeed, they are not often seen larger than an orange. As far as such a cyst itself is concerned, it may be regarded as unilocular, although in most instances traces of multilocularity will be found in its interior; but in connection with the main cyst there will be found smaller ones of a similar character, some of which contain ova. Or, two, or three cysts may develop simultaneously in the same ovary, and may remain separate, one being larger than the rest (so-called "oligo-cysts"); they seldom coalesce to form a single cyst-cavity. The fluid within these cysts is of a thin, serous character, having rather a low specific gravity (1.012 to 1.015), and containing albumin and sodium chloride; under the microscope only a few epithelial cells are seen. The anatomical relations of the tumor are the same as that of the ovary; its pedicle is similar to that of other ovarian cysts.

Tubo-ovarian cysts deserve a brief mention. They are formed, as their name implies, by simultaneous dilatation of a Graafian vesicle and of the corresponding Fallopian tube; the fimbriated end of the latter becomes adherent to the surface of the ovary opposite to a ripe ovisac, which ruptures and discharges its contents, when circumscribed peritonitis causes permanent adhesion, and a catarrhal process results in dilatation of the common cavity. The tumor has been compared in shape to a retort, the resemblance being more or less perfect according to the extent to which the tube is dilated. There is usually a furrow indicating the line of fusion between the tube and the cyst; moreover, traces of the fimbriæ can often be seen on the inner wall.

Proliferous cysts of the glandular variety (multilocular colloid) may reach an enormous size (seventy-five or one hundred pounds), and are usually of irregular shape and variable consistence, portions of the tumor being nearly solid, while others are fluid. There may be one large cyst, containing in its interior several smaller ones, or two or three cavities of nearly equal size may exist, separated from one another by thick partitions. The smaller secondary or "daughter-cysts" are outgrowths from the wall of the primary cyst, and they may grow so rapidly as to entirely fill the cavity of the latter, so that its original character is obscured. More frequently the partitions between contiguous secondary cysts are destroyed, and several cavities are thrown into one; the traces of this fusion are long preserved in the shape of trabeculæ on the inner lining of the central sac. Three distinct layers are easily distinguished in the cyst-wall, although one or more of these may be wanting—an outer serous, a middle fibrous, and an inner cellular. The wall of the principal cyst varies greatly in thickness, being rendered thick in some localities by the coalescence of the walls of several secondary cysts. Various secondary changes are evident to the naked eye, the most common being calcification (in the form of thin scales, scattered over the interior of the cyst), fatty and atheromatous degeneration, infarction, etc. The contents are exceedingly variable; indeed, from the different loculi of the same cyst four or five fluids, with totally different physical characteristics, may be obtained. It is usually of lower specific gravity in the principal cyst than in the secondary ones, which often contain a clear, semi-solid, colloid material, while the fluid in the central sac is turbid, and may be green, gray, red, or chocolate-colored, according to the presence of hæmorrhage, suppuration, fatty degeneration, etc. The specific gravity varies from 1.010 to 1.030. Spontaneous coagulation of pure cyst-fluid never occurs. Chemically, the reaction is usually neutral; albumin is present in large

amount, also paralbumin, cholesterin, fats, sodium chloride etc. Eichwald has divided the substances found in such fluids into the "mucin-group" and "albumin-group," the former being most abundant in colloid material. The microscopical appearances will be described in the following section.

Papillomatous cysts (cystoma proliferum papillare) are distinguished from those of the multilocular colloid type by the tendency of the lining epithelium to proliferate and form cauliflower-excrescences instead of secondary cysts. It is, of course, impossible to draw a sharp line of distinction between the two forms, since they are sometimes combined in the same growth. Their distinguishing characteristic is the presence upon their inner wall of masses closely resembling papilloma of the bladder; these may be scattered sparsely over the interior of the cyst, or may grow so luxuriantly as to completely fill it and to burst through the wall and spread over its exterior, forming secondary deposits in the peritoneum. Such cysts do not reach a very large size, and have but few secondary loculi. The fluid is wanting in that peculiar colloid character which marks the contents of the cystoma proliferum glandulare. These tumors are often bilateral (in seventy-five per cent. of the cases), and differ from other cysts in being outside of the peritoneum; they sometimes grow between the two layers of the broad ligament (intra-ligamentous cysts), in which they are enveloped as in a capsule. They are frequently accompanied by ascites, especially if the papillary growths have become extra-cystic, and tend to become anatomically (as they are regarded clinically) malignant, especially after tapping.

In connection with this variety of cyst may be mentioned true papillomata ovarii, which should really be classed among the solid growths, since their only relation to papillomatous cysts lies in the fact that they spring directly from the outer surface of the ovary (from the germinal epithelium?). In a specimen in my possession, while one-half of the ovary is apparently normal, the other half is transformed into a cauliflower-mass as large as an English walnut. The tendency of these masses to proliferate and extend to the adjacent peritoneum shows that they approach closely to malignant growths. Anatomically they are identical with the similar masses found in proliferous cysts. This peculiar metastasis, it should be noted, is not confined to papillomata, since it has been observed in cases of multilocular colloid cysts, the secondary growths of which have been described as myxoma (or pseudo-myxoma) peritonei.

So-called "papillary cancer" of the ovary is nothing more or less than papillary growths in the interior of an ovarian cyst that have become malignant. These may coexist with the ordinary cauliflower-masses, and their presence may be unsuspected until they are examined microscopically; in fact, the possibility that malignant disease may be present should render us suspicious of every cyst the lining epithelium of which shows a tendency to rapid proliferation.

The vascular supply of an ovarian cyst is quite rich—the arteries run in the middle lamella of the fibrous coat, their capillaries in the sub-epithelial layer, while the veins lie in the outer lamella. These increase in size as we near the pedicle, and are accompanied by large lymph-vessels provided with valves. Nerves of considerable size have also been traced into the cyst, though their ultimate terminations are unknown.

The pedicle of the cyst deserves some mention, as it is of such great surgical importance. It is subject to every possible variation as regards its length, breadth, thickness, and the number and size of the contained vessels. It may be a slender stalk not larger than the little finger, or a thick, fleshy mass as broad as the wrist. These variations in size depend upon the changes in the thickness of the tube and broad ligament. The pedicle is described as consisting of the tube, the broad ligament, and the utero-ovarian and round ligaments, though the latter is not properly included, since it is not connected with the cyst and is seldom or never ligated. The arrangement of the venous plexuses will be understood by reference to the normal anatomy of the broad ligament; the vessels are often immensely dilated, especially the veins. The danger of torsion is greater when the pedicle is long and slender. Sessile, or non-pedunculated, cysts are often intra-ligamentous and firmly adherent.

Minute Anatomy.—A section through the wall of a simple cyst shows that it consists essentially of a layer of fibrous tissue lined by a single row of columnar, or rather, cuboidal epithelia. The fibrous layer is of variable thickness, and may be subdivided into two strata—an outer, in which the tissue is loose and interlacing, and an inner, in which the fibres are denser and more nearly longitudinal in direction. These layers correspond to the tunica fibrosa and tunica propria of the original ovisac; in some cases a localized thickening in the wall of the cyst seems to represent the remains of the cortical zone of the ovarian stroma. Secondary changes are sometimes observed, especially fatty degeneration of the lining epithelium; inflammatory processes lead to considerable thickening of the cyst-wall, which, however, may be due to external causes, such as peri-oöphoritic adhesions. Evidences of proliferation of the epithelium (either the glandular or papillomatous forms) are absent. The fluid presents few objects of microscopical interest, usually containing scattered epithelial cells, normal or fatty; blood-corpuscles and masses of pigment indicate hæmorrhage into the cyst. We should look for ova in the accompanying smaller cysts, as their presence serves to confirm our opinion with regard to the origin of the larger ones.

Sections through the wall of a compound cyst present different appearances according as the glandular or papillomatous element predominates. The wall of the principal sac consists of firm fibrous tissue, of variable thickness, sometimes separable into two, less often into three, lamellæ, in which will be found, from within outward, the capillaries, arteries, and veins. Smooth muscle-fibres may be found, especially along the larger vessels and near the pedicle (Sinéty). Resting upon the loose sub-epithelial layer of fibrous tissue is a single layer of cuboidal epithelium, which, in consequence of long pressure, may be flattened; some writers affirm that there are several layers, the lower ones being flattened and polyhedral. Ciliated cells are occasionally found, as well as the so-called "beaker-cells," which are simply ordinary epithelia distended by thin, mucoid contents. Large multinucleated cells, cells with serrated edges, and other transition-forms are sometimes seen. Tubular, sometimes acinous, follicles, similar to the gastric glands, are scattered throughout the field, some of them plugged with mucus; these represent the initial process in the formation of secondary cysts.

Commencing cysts may also be represented in the section by small, thin-walled cavities lined by cylindrical epithelium. In the same cyst may be found papillomatous masses, which on section are found to consist of outgrowths from the fibrous layer, covered by a single layer of columnar (sometimes ciliated) epithelium; in the midst of the delicate fibrous tissue are round and spindle cells. Secondary and tertiary projections extend from the primary one. Adjacent villi coalesce and form cyst-cavities. The dendritic masses are quite vascular. In short, the microscopical appearances are those of simple adenoma. Degeneration of the cyst-wall (fatty or calcareous) will be recognized by the characteristic changes in the cells; such changes are nearly always localized. In many spots where degeneration has occurred the epithelial lining may be entirely wanting. Suppuration, or even necrosis, is sometimes observed. The papillomatous masses may grow so rapidly as to cause atrophy and, finally, perforation of the wall; the growths should be carefully examined in these cases, as they will often show a transition to carcinoma. Inflammatory thickening of the cyst-wall is not uncommon, so that the differentiation of a fibrous tumor from a fibro-cyst is not always easy. The microscope will reveal, not only the epithelial lining of the ovarian cyst, but the cicatricial or indurated character of the tissue in the thickened portion of the wall.

Under the microscope the fluids from different cysts vary not a little as regards the character of their cellular elements. Aside from the cast-off epithelial cells, there are often found blood- and pus-corpuscles, pigment-granules, fat-globules, Glüge's corpuscles, and cholesterin-crystals—all of which indicate the presence of retrograde changes, the extent of which can be estimated to some degree by the number of such elements. The cells present different degrees of fatty and granular degeneration. The so-called "ovarian cell," on the pathognomonic character of which Drysdale has laid so much stress, is merely a swollen and degenerated epithelial cell that contains a number of highly refracting granules, which are more clearly defined after treatment with acetic acid, and are thus distinguished from the smaller pus-corpuscle in which two or more nuclei appear after exposure to the same reagent. Since they are found in the fluid of other cysts the lining of which is undergoing fatty degeneration, they possess no positive diagnostic value; but their absence from a cyst-fluid is a sign of some negative importance, as pointing to the fact that the cyst is probably not ovarian. Large flakes of epithelium and sprouting cell-masses possess some significance, the former pointing to extensive exfoliation of the lining, the latter to possible malignant degeneration.

Clinical History.—It is difficult to condense the varied symptomatology of ovarian cysts within the narrow limits of this paper, since a separate monograph might be written on this branch of the subject alone. A woman may have a tumor that extends to the umbilicus without suffering any inconvenience except from its weight, or, on the other hand, she may have an intra-pelvic cyst not larger than an orange that causes her great distress and affects her general health. The following is a brief sketch of the clinical features in a typical case: A patient who may have had no previous pelvic trouble begins to have some disturbance of her menstruation, amenorrhœa being more common than menorrhagia. Dysmenorrhœa may or may not be present. If one ovary remains intact there may be no menstrual trouble, and pregnancy may occur. Vesical irritability early appears, due to pressure on the neck of the bladder, while the presence of irritation of the rectum, constipation, and hæmorrhoids also gives evidence of mechanical obstruction; backache, and pains following the course of the pelvic nerves, and extending down the thighs, point to the presence of some local morbid condition. An attack of peritonitis at this stage may fix the tumor and further aggravate the pelvic troubles.

After the cyst rises out of the pelvis the before-mentioned pressure-symptoms are relieved; it now occupies the inguinal region, and is often noted by the patient as distinctly unilateral. If the pedicle is long, it may move about as she changes her position in bed. As it grows it approaches the median line at the umbilicus, rises above the latter point, and begins to cause uniform distention of the abdomen, with a new set of pressure-symptoms referable to the thoracic and abdominal viscera, which may later be exchanged for evidences of actual organic disease of the affected organs. The weight of the tumor causes an unpleasant feeling of distention and weariness on making slight exertion, and the aching pains in the back and legs reappear. The diaphragm is pushed upward, and there is dyspnœa on exertion, finally becoming constant. The stomach, constantly compressed by the growing tumor, becomes extremely irritable, so that the patient can take but little food at a time and vomits easily. The intestines are crowded into a small compass behind the mass and share in the general disturbance, as evidenced by alternate constipation and diarrhœa, and sometimes by complete obstruction. Signs of venous obstruction, such as enlargement and varicosities of the superficial veins, especially those in the abdominal wall, œdema of the lower extremities and of the vulva, and sometimes ascites, develop. The patient already begins to show the drain upon her vital powers; she is restless and anxious, cannot find a comfortable position, and her sleep is disturbed.

As the cyst increases still more, the lungs are compressed, the heart dislocated, and extreme dyspnœa and palpitation are noted; sudden death from heart-failure, from pulmonary congestion, or from an intercurrent attack of bronchitis, is imminent. The patient cannot sleep unless her head is elevated. The gastric irritation is now excessive, and obstinate vomiting may ensue, threatening death from inanition. Congestion of the kidneys results from pressure on the renal vessels, and albumin may appear in the urine, though without evidences of organic changes in the kidneys. Emaciation has been all the time steadily progressing and is now marked, especially in the face, which assumes the "facies ovariana" so graphically described by Sir Spencer Wells, as marked by "the expression of anxiety and suffering, the furrowed forehead, the sunken eyes, the open, sharply defined nostrils, the long, compressed lips, the depressed angles of the mouth, and the deep wrinkles curving around these angles." Death finally occurs from pure exhaustion. But the complete train of symptoms thus described is rarely observed at the present day, since, thanks to the general intelligence of the profession and the spirit of modern abdominal surgery, few patients are allowed to perish thus without some attempt being made to relieve them. Physicians of the present generation are more familiar with the earlier than with the later symptoms of an ovarian cyst.

It is highly important that every practitioner should be able to recognize promptly the symptoms denoting the occurrence of certain complications and accidents which demand instant and radical treatment. These are hæmorrhage into the cyst, suppuration of its contents, twisting of the pedicle, and rupture. If the attendant believes, or only suspects, that one of these conditions is present, it is his duty to open the abdomen without delay, even if he has shrunk from doing so before. In order to economize space, the first two complications will be described as consequences of torsion of the pedicle, since they commonly follow that accident.

A cyst of moderate size, perfectly movable, and having a long pedicle, may undergo gradual axial rotation until the pedicle becomes strangulated. The fact that most tumors thus affected are situated on the right side, and that the twist is from left to right, substantiates Mr. Tait's idea that the accident is due to the passage of fæces through the adjacent rectum; the chief symptom, to use his words, is "the sudden accession of severe abdominal pain and tenderness, followed immediately by vomiting, which soon becomes green." A rapid, feeble pulse, and evidences of internal hæmorrhage and collapse may speedily follow. The large vessels that supply the cyst are strained to their utmost, and often rupture into the abdominal cavity. The sac rapidly increases in size, and is extremely sensitive on palpation; in a case in the Woman's Hospital, which terminated fatally in a few hours from acute peritonitis, the cyst was perfectly black, its contents being transformed into a mass of tarry, coagulated blood. If the patient survive the shock and loss of blood (the shock itself is frequently out of proportion to the size of the cyst), she will probably succumb from acute peritonitis or subsequent suppuration and gangrene of the sac, the symptoms of which will be a succession of chills, characteristic elevation of temperature, hectic, rapid emaciation, sweats, and finally general peritonitis, if death does not ensue beforehand from septicæmia. Suppuration may also result from inflammation of the lining membrane in consequence of tapping or other injury (less often spontaneously). The symptoms and result will be the same in either case.

Rupture of the cyst sometimes occurs spontaneously, but more often in consequence of violence. If the fluid is unirritating, little, if any, reaction may follow. I recall two cases of colloid cystoma in which but slight disturbance followed the accident; in fact, in one patient it was unsuspected before the abdomen was opened. Although the mortality is estimated by Aronson at forty-one per cent., cases are on record in which simple cysts (parovarian ?) have apparently been radically cured in this way. The rupture of a large cyst is indicated by the sudden acute pain, evidences of collapse, and marked

change in the form of the enlargement. The mass becomes much more diffuse, and if a large quantity of colloid material is loose in the cavity it may give a peculiar, jelly-like sensation on palpation. If the patient does not succumb to shock, fatal peritonitis is apt to supervene. Nature's attempt to dispose of the escaped fluid is shown by an excessive flow of urine. In the case of papillomatous and myxomatous cysts, secondary disease of the peritoneum may be a direct consequence of the prolonged contact of their contents with the peritoneum.

A common complication of ovarian cyst is peritonitis and the subsequent formation of adhesions. The presence of the latter is indicated by recurrent attacks of peritonitis and general tenderness over the area of the tumor; it may become adherent to any or all of the pelvic organs, and to most of the abdominal viscera, thus adding further symptoms to those already due to compression. The entire extent and character of these adhesions can never be accurately estimated until the abdomen is opened. Occasionally the cyst-wall may ulcerate at the point where it is attached to a hollow viscus, and may discharge its contents in the manner described in the section on dermoids.

Diagnosis.—There are no characteristic subjective symptoms of simple ovarian cyst, other than the disturbance produced by any large abdominal tumor which displaces or compresses the viscera and impairs the general health. It is not uncommon to find cysts that are universally adherent, and are even surrounded by evidences of recent peritonitis, when the patient has given no history of inflammation within the abdomen. On the other hand, the complications which have been mentioned may be attended by most serious local and general symptoms, such as shooting pains, elevation of temperature, collapse, and even sudden death. Intra-pelvic cysts are sometimes discovered by accident in patients who are entirely unaware that they had any local trouble. Most of the points that have been noted with regard to the recognition of dermoids will apply here. Cystomata cause no characteristic symptoms, and are seldom associated with menorrhagia. On practising the bimanual a non-adherent intra-pelvic cyst will be recognized as a tense, globular, fluctuating body, usually situated behind the uterus and moving independently of that organ, which is often displaced forward. Simple cysts do not, as a rule, contract firm adhesions at this stage of their growth, and may be lifted up on the finger and mapped out between the two hands, especially if the patient is anæsthetized. A suggestion of Hegar's is of value in this connection, although the procedure recommended by him should not be employed indiscriminately. It is intended to aid the examiner in determining the presence and exact origin of the pedicle of a movable tumor, situated above the pelvic brim, and is therefore not applicable to sessile growths. The cervix uteri is seized with a volsella and the entire organ is drawn steadily downward in the axis of the pelvis, while its posterior and lateral surfaces are thoroughly explored by the rectal or recto-abdominal touch. If a pedicle is felt extending outward from the fundus to the tumor, it is highly probable that the latter is ovarian. By placing the patient in the genu-pectoral posture the tumor often falls forward by its own weight. Schultze recommends the following manipulation under similar conditions: An assistant grasps the abdominal wall with both hands and pushes it toward the symphysis, then "gathers in the slack," as it were, and draws it upward, at the same time raising the tumor out of the pelvis and making its pedicle "taut." The examiner then practises the bimanual, sinking the upper hand into the abdominal wall below the tumor so as to grasp and explore the lateral borders of the fundus uteri. The relations of the pedicle will then be made out as before. This method is best applied when the muscles are relaxed by an anæsthetic. A rectal examination may throw light upon a doubtful case. Withdrawal of a small quantity of fluid for microscopical examination is legitimate when the cyst is easily accessible through the posterior fornix.

A retro-uterine ovarian cyst may be mistaken for either of the conditions mentioned in the section on dermoids; a careful history of the case will usually serve to exclude sanguineous or purulent collections (hæmatocele, pelvic abscess), while the shape of the tumor and its distinct fluctuation will render it probable that it is not a solid growth, either of the uterus or ovary. It would seem unnecessary to caution the reader against the possibility of mistaking early pregnancy (especially in a retroverted uterus) for a small cyst, had not this error in diagnosis been made by the most accomplished gynecologists. In women well advanced in life, whose menstruation has been irregular, who have not had any children for a number of years, and who show none of the usual signs of pregnancy, the diagnosis of this condition is often extremely difficult. The patient may be very stout, her cervix may be lacerated and the lips everted and softened, and the uterus may closely resemble the organ in the common condition known as subinvolution. If there is any doubt, the patient should be examined under ether, when Hegar's sign of pregnancy (triangular shape of the corpus uteri with marked projection of the anterior aspect) will be found valuable. It is a far less serious matter to produce abortion by the diagnostic use of the sound than to perform explorative laparotomy and find a gravid uterus instead of a cyst. Such a uterus has even been tapped before the error was discovered. Pregnancy may, of course, coexist with a small cyst. In these cases as well as in those of suspected extra-uterine fœtation, much depends upon the menstrual history; but here, as under all circumstances, it is often necessary to keep the patient under careful observation for some time before coming to a definite conclusion.

It may be impossible to distinguish a small adherent cyst, lateral to the uterus, from an encysted peritonitic effusion; such laterally situated cysts are usually parabligamentous. Here an examination of the fluid will be of service; the same applies to small parovarian cysts. Distended tubes of large enough size to be mistaken for ovarian cysts are not so very frequent. They are often double, are continuous with the uterus, of a tortuous shape, and do not give such distinct fluctuation. The history (sterility, menstrual irregularities, dysmenorrhœa, and recurrent peritonitis) will point to the true condition. But a hydrops tubæ may be of large size, so as to exactly resemble an ovarian or tubo-ovarian cyst, even after the abdomen is opened. From an examination of many specimens of fluids from hydro- and pyo-salpinx, I have been led to attach considerable importance to the discovery of numbers of ciliated columnar cells as diagnostic of tubal contents. When the tumor is accessible through the fornix, a drop of fluid may be withdrawn with a hypodermatic syringe for microscopical inspection. The procedure is not entirely devoid of danger in the case of very acrid pus from a pyo-salpinx. The differential diagnosis between ovarian and parovarian cysts will be considered subsequently. It should not be forgotten that the spleen or a kidney may be found in the pelvis, while malignant disease of the pelvic organs or bones, and the rare condition, echinococcus-cyst, are possible contingencies.

The differential diagnosis between abdominal tumors is described at length in every text-book and monograph, yet no descriptions can supply that intuitive appreciation of the "feel" of a tumor which is only gained by years of experience. As Mr. Tait says, the "sense of resistance" given by different growths, "it is quite impossible to teach." While a few diagnosticians have attained to such a degree of skill that they can, by simple palpation of the abdomen, obtain an amount of information which, to the uninitiated, seems perfectly marvellous, most men can only avoid gross errors by exhausting every means of diagnosis. The true way to arrive at the probable nature of an abdominal tumor is to consider every possible condition that could cause enlargement, and then to exclude them one by one. To do this we must first obtain an exhaustive history. The possible existence of extra-pelvic disease must never be lost sight of; many unpardonable errors in the diagnosis of tumors have been made by specialists who have allowed themselves to

ignore everything but the pelvis and its contents. A general practitioner would not be so likely to open the abdomen for dropsy of cardiac, renal, or hepatic origin, as has been done by laparotomists under the idea that they had to do with an ovarian cyst. A general history, then, is highly important. The patient's attention is, of course, directed to her abdomen; she has noticed that it is growing larger; and that may be all the information that she can offer, except that she has various pulmonary, gastric, vesical, and other disturbances, due to pressure, with perhaps venous obstructions, œdema of the lower extremities, etc. Or, if she is in the advanced stage, emaciation and the "facies ovariana" may be significant. The most important fact that she can state is that the tumor was distinctly unilateral at first, and gradually approached the median line.

Having placed the patient on the back and exposed the abdomen, we first make an inspection of it, noting its general contour, the condition of the superficial veins, the appearance of the umbilicus, etc. Palpation is next practised, by placing the palm of the hand on one side of the abdomen and tapping lightly with one or two fingers of the other hand at a point directly opposite; one hand should be kept stationary, while the percussing finger moves about over the tumor. An inexperienced examiner will readily mistake the "superficial subcutaneous wave" in a stout subject for the deeper wave in a cyst. "To muffle this fat-thrill," says Goodell, "the ulnar edge of the hand of an assistant is laid along the linea alba while the surgeon percusses the abdomen. The pressure thus exerted acts precisely like the damper-wedge of the piano-tuner, which muffles the sound of one string while its fellow is being tuned." Palpation not only gives definite information regarding the tension of the cyst and the fluidity of its contents, but we can by its aid determine with some exactness, by the manner in which the impulse is transmitted, whether the cyst is simple or multilocular, or contains portions that are solid. It is sometimes possible to detect adhesions to the anterior abdominal wall by the peculiar rubbing sensation which we get on moving the skin over the tumor. Careful examination of a cyst (unless it is so large, or is so complicated by ascites, that its relations are obscured) will usually show that, while its upper and lateral boundaries are well defined, its lower limit shades off into the pelvis and cannot be determined showing that the growth originated in the latter cavity. As regards the detection of fluctuation by external palpation, the reader should remember that until a cyst has reached the umbilicus, the sensation communicated when it is grasped between the hands is rather that of an elastic body (Olshausen). A multilocular cyst of large size may give the same elastic feel, but usually careful palpation will develop a peculiar, jelly-like vibration, or, if it is composed of numerous loculi, there may be absolutely no fluctuation. In a thin-walled ovarian or parovarian cyst, containing watery fluid, exquisite fluctuation may be obtained, so that it is difficult to believe that the fluid is not free in the abdominal cavity.

Percussion gives some additional information. With the patient lying on her back, a dull percussion-note is obtained over the entire surface of the tumor, shading off above and at the sides into the tympanitic resonance of the stomach and intestines. There is no line of difference between the umbilicus and the pubes. If the tumor is so large as to fill the entire abdomen (it is assumed that in the case of smaller unilateral growths no special difficulties are presented), no difference will be observed in the percussion-note whether the patient is standing, or is reclining on either side.

Auscultation rarely adds much to the information already gained by the preceding manipulations; the negative results may be important (absence of the fœtal heart-beat, of intestinal gurgling, etc.). Rarely a murmur is heard in the vessels of the tumor, especially when these are of unusual size, or when there is obstruction to the blood-flow. A peculiar rubbing or creaking sound has been described as indicating the presence of adhesions between the anterior surface of the cyst and the abdominal wall. As Tait properly observes, it merely shows that the opposed peritoneal surfaces are dry, so that we should expect to find adhesions absent, rather than present, over this area. A kind of rubbing sensation is sometimes imparted to the finger and ear in cases in which a quantity of colloid material has escaped from a cyst and forms a layer between it and the anterior abdominal wall; but it may also be caused by the moving about of the colloid contents within an unruptured cyst. It is of slight importance as a diagnostic sign.

The vaginal examination of a patient with a large intra-abdominal cyst reveals but little that was not already discovered by external palpitation. As the tumor causes a general bulging of the fornix, or frequently none at all, no idea of its relations can be gained by the examining-finger alone, although the bimanual may furnish important information regarding its relations, mobility, etc. The cervix uteri is often so high up in the posterior fornix that it is difficult to reach it, the uterus being displaced forward and often pushed over to one side of the pelvis; retroversion is not common. The organ is not usually enlarged, unless from causes independent of the tumor (pregnancy, subinvolution, fibroid); hence the sound enters to the depth of three or three and one-half inches, with a decided anterior curve. The bladder is generally of normal size, but cases are on record in which it has been drawn up above the pubes and has covered the anterior surface of the cyst.

Having satisfied himself that he has to do with a cystic tumor that originated within the pelvis and is probably ovarian (or parovarian), the expert seeks to obtain some more exact information regarding the site and character of the pedicle, the presence of adhesions, and the probable nature of the cyst itself, whether simple, multilocular, proliferous, malignant, etc.; it is hardly necessary to add that it is a matter of daily experience for the most accomplished diagnosticians to find, on opening the abdomen, a condition of affairs exactly the reverse of what they had predicted. With our present imperfect methods, this is not surprising. How shall we decide upon the probable structure of a given cyst? The history gives some clew, although it may be misleading. For special symptoms pointing to malignant degeneration, suppuration, hæmorrhage, etc., the reader is referred to the section on Clinical History. When the abdominal wall is very thick it may be impossible to discover anything save that a tumor exists; if it is thin and relaxed we may both see the irregular, nodulated shape of the growth, which proves that it is multilocular, and may further demonstrate that it is of this character by practising palpation with the fingers of both hands over circumscribed areas, when the difference in the fluctuation at different points will indicate the presence of several loculi, containing fluids of varying density. It is of course impossible to say positively whether a sac does or does not contain papillomatous growths, although this may be suspected when a cystoma gives the impression of being solid, or semi-solid. The presence of a parovarian cyst may be suspected when the tumor is of slow growth, causes little, if any, general disturbance, has thin walls, and gives with the lightest tap a perfect wave of fluctuation which is quite superficial, and only differs from that observed in ascitic fluid (in patients with thin abdominal walls) in being completely arrested at the opposite border of the cyst, *i.e.*, in being confined strictly to the area of dulness. It is not always possible to tell which ovary is diseased, as a cyst with a long pedicle may lie in the side of the abdomen opposite to that from which it arose. Double cysts can be distinguished when both are small and either are intra-pelvic, or have just risen above the brim; even when they are in contact a groove may sometimes be felt between them. If adhesive peritonitis occurs, the two growths may be so fused together that it is difficult, even at the autopsy, to determine the original condition. If the presence of two tumors is demonstrated, the chances are in favor of their being malignant (anatomically or clinically), since seventy-five per cent. of all double ovarian cysts are of the papillomatous variety.

Adhesions are regarded as far less significant now than

they were in former years, when abdominal surgery was hampered by a spirit of timidity that is scarcely comprehensible to modern operators; moreover, intra-pelvic and intestinal adhesions, which are most dreaded by surgeons, are extremely difficult of recognition before the abdomen is opened. As the prognosis is modified by their known existence, the method of detecting them may be described briefly. Under favorable circumstances (thin and relaxed abdominal walls), with the patient in the dorsal posture, a non-adherent cyst which does not distend the abdomen to its utmost extent will be seen to move downward at each deep inspiration; this is only a negative sign, and the reverse (an absence of movement with parietal adhesions) is not always true. Sensitiveness on moderate pressure over the tumor, with a history of a recent attack of peritonitis, will render the diagnosis of adhesions extremely probable. Collections of ascitic fluid in front of the growth (encysted peritonitis), are, in the opinion of Olshausen, indicative of parietal adhesion. Adhesions deep within the pelvis, to its floor or walls, can only be suspected on general principles, by the sensitiveness to pressure made through the vaginal roof, and by the fixation of the tumor; the determination of the mobility of intra-pelvic cysts has been described elsewhere. If the cyst has been tapped several times the existence of adhesions may safely be assumed.

Adhesions to the abdominal viscera are of great significance during ovariotomy and have an important bearing upon the prognosis, but it is possible to infer their probable presence only by marked disturbances in the adherent organ. I have noted on several occasions that patients, in whom a loop of intestine was firmly adherent to the cyst suffered from severe localized, colicky pains, especially during the process of digestion, which I attribute to the tugging of the imprisoned gut in its attempt to share in the peristaltic movement; this phenomenon is especially marked in cases in which the intestine becomes adherent to the abdominal wound after laparotomy. Adhesions to the stomach or liver may be suspected in cases in which the cyst is so large as to be in contact with those viscera, and when it is depressed simultaneously with them during deep inspiration. Adherence of the tumor to the uterus or bladder is determined by lifting it upward and noting whether the organ in question moves with it; pelvic adhesions undoubtedly exist when the intra-pelvic portion of a cyst remains fixed as the abdominal portion is pushed upward or moved from side to side. A sound passed into the bladder at once gives the relation of that viscus to the tumor; if, after emptying the bladder with a catheter, it is still drawn up over the anterior aspect of the cyst, it is doubtless adherent to the latter.

The manipulations practised for the purpose of determining whether the pedicle is long or short have already been mentioned. Sometimes the cyst has no pedicle at all, being situated beneath the peritoneum, either in the broad ligament or on the pelvic floor. An intra-ligamentous cyst is recognized by its lateral situation with regard to the uterus, to the side of which it is frequently adherent while the two move in common. If the tube can be felt, it will be found to run outward across the upper surface of the cyst.

Differential Diagnosis.—An ovarian cyst occupying the abdomen must be distinguished from every variety of abdominal enlargement, however produced. Such enlargements can be grouped most readily by reference to the organ in which they originate. First in order of frequency is ascites, whether general or encysted; then come enlargements of the uterus, bladder, omentum, and intestines, kidney, spleen, and liver; and lastly, tumors and adipose hypertrophy of the abdominal wall. Abdominal aneurism, retro-peritoneal tumors or hæmorrhages, and circumscribed abscesses, situated in various localities within the pelvis and abdomen, need not detain us, because it is only exceptionally that they have been mistaken for ovarian cysts.

Ascites.—The more obvious causes of effusion (renal, cardiac, hepatic) ought not to be overlooked, especially if œdema of the lower limbs and anasarca are present; the latter rarely occur as complications of ovarian cyst. But there are obscure forms of ascites, due to chronic peritonitis, enlarged glands, malignant disease, etc., conditions which often elude the most astute observer. I have on two occasions seen fatal cases of laparotomy, in which the operation was performed by distinguished surgeons, where the condition was simple ascites, due to causes which could not be definitely ascertained at the autopsy. In simple ascites the differential diagnosis must be based principally upon the physical examination.

On inspection (the patient lying upon the back) the abdomen appears flatter and broader than in ovarian cyst, while there is a marked projection of the lateral abdominal parietes. Turning the patient on her side, the shape of the belly is not changed in the case of ovarian disease, while in ascites there is evident bulging of the lower side, due to the gravitation of the fluid. On measuring the circumference of the abdomen it will be found to be largest at, or just above, the level of the umbilicus in ascites, but the greatest circumference will be below that point in ovarian cyst; in consequence, the distance between the symphysis and the umbilicus in the latter condition considerably exceeds that between the umbilicus and the ensiform cartilage—a difference which does not exist in ascites. On palpating an abdomen which is distended by ascitic fluid, a visible superficial wave of fluctuation will follow the lightest tap of the finger, and will be transmitted from one flank to the other, without reference to the area of dulness; in a large ovarian cyst, on the contrary, the wave, no matter how distinct it may be, will be confined to the dull area, and will be sharply limited by the opposite edge of the tumor. Complications, such as might obscure this sign, will be considered subsequently.

Percussion over an extensive ascitic accumulation gives a tympanitic note around the umbilicus, with dulness elsewhere; as the patient is turned alternately upon either side, tympanitic resonance is noted over the flank that is uppermost, while a similar variation in the limit of dulness will be observed when she assumes a sitting posture. The explanation is, of course, purely mechanical, the variation being due to the changes in the position of the fluid, which allow the intestines to float upward. Over an ovarian cyst there is a universal area of dulness, while in the flanks and just below the ribs the tympanitic note of the colon is present, unless the tumor is so large as to completely obscure it. No difference is noted with change of position. On making a vaginal examination in a case of ascites, the uterus will be found to be perfectly movable, while there will be a general depression of the fornix, giving the impression that the cervix is retracted.

The omentum may be so thickened (cancer, tuberculosis, excessive deposit of fat) that there is dulness over the umbilical region, or peritonitic adhesions may prevent the intestines from floating upward; unusual thickness or œdema of the abdominal wall, fæcal impactions, etc., may also interpose obstacles. So-called "encysted dropsy," in which a circumscribed collection of fluid is confined by peritonitic adhesions, is readily mistaken for ovarian cyst. The history of the case, the situation and immobility of the tumor, and the entire absence of any relation between it and the pelvic organs, will give a clew to its true character.

In every case of doubt exploratory puncture may settle the diagnosis. Ascitic fluid is clear, yellowish or greenish, sometimes turbid or sanious; it has a specific gravity, rarely above 1.015, and frequently coagulates on standing, especially if it be mixed with blood. The diagnostic importance of the "sprouting cells" has been alluded to elsewhere. Pus and fatty-degenerated epithelial cells may be present (though the latter are rare except in malignant dropsy), and few, if any, elements resembling the "ovarian cell." Puncture of a cyst may be without results, as the fluid is too thick to flow; this negative evidence is against ascites. If cyst-fluid is withdrawn, its specific gravity will seldom be as low as in the former condition, and spontaneous coagulation almost never occurs, while the microscope shows large numbers of the peculiar cells already described. Waldeyer goes so far as to regard the absence of cylindrical epithelial cells as proof positive that a given fluid is ascitic. It must not

be forgotten that an ovarian cyst may co-exist with ascites, when the former may easily escape detection, especially if the abdomen is greatly distended; the diagnosis is often cleared up by withdrawing a portion of the ascitic fluid. Not infrequently malignant nodules in the peritoneum are plainly felt after a few ounces of fluid have been removed, and the patient is spared an explorative incision. Some surgeons prefer to resort to the latter measure in all cases of doubt, claiming that in this way a removable tumor is often discovered, and the patient is thus radically cured, whereas, after tapping alone there always remains some doubt regarding the exact pathological condition. Perhaps a combination of the two methods of diagnosis might be recommended, the surgeon being prepared to operate if the information obtained by the puncture is not sufficiently definite.

Pregnancy.—The general practitioner can afford to bear in mind the possibility of error in this direction, when he remembers that the most famous laparotomists have opened the abdomen to find that the tumor which they mistook for a cyst was the gravid uterus. The history may be entirely negative or misleading, especially if menstruation has been irregular, if the patient's age is somewhat advanced, and her general condition is such as to warrant the impression that she is suffering from some chronic disease. Hydramnios and death of the fœtus may render the condition still more obscure. Certain cardinal facts should be borne in mind, chief among which are the existence of contractions in the gravid uterus, of fœtal movements and heart-beats, the characteristic alterations of the portio vaginalis (especially in primiparæ), and the fact that the latter is continuous with the tumor—assuming that it is impossible to recognize a fœtal part. But every characteristic sign may be wanting, when the only proper course is to *wait*, keeping the patient under constant observation. The possibility of pregnancy and ovarian cyst co-existing should not be forgotten, but under these circumstances the history of the case has usually shown the pre-existence of a tumor, although sometimes it is not discovered until during or after labor.

Fibroids and Fibro-cysts of the Uterus.—A. Fibroids. The history of the patient will show that the tumor was of comparatively slow growth, that when first noticed it was near the median line, and that menorrhagia was a prominent symptom—unless the tumor is sub-peritoneal and is attached by a long pedicle. A semi-solid colloid cyst may convey to the palpating finger the impression that it is quite solid, but it will rarely feel so firm and unyielding as a large fibroid; on examining per vaginam a dense mass is felt which often fills the pelvis and is immovable. If the entire growth is seized by an assistant and is moved in different directions, the uterus will be felt to move with it; the depth of the uterine cavity, as measured by the sound, will probably be found to be upward of four inches. The patient's general health, it may be stated, is usually very fair in the case of fibroid disease; her facies is anæmic rather than "ovarian."

B. Fibro-cysts. I am sure that these tumors are not so rare as they were formerly represented, before laparotomy began to be performed so generally. They are very often mistaken for ovarian cysts, for unfortunately there is no sure means of distinguishing the two except by a resort to abdominal section. The history is an uncertain guide; they grow slowly and often remain solid for a long period—an important point if the patient has remained under observation for some time. The general health often remains surprisingly good, and menorrhagia is frequently absent, if the tumor is pedunculated. The growth is median, is continuous and moves with the uterus, and the cavity of the latter is usually elongated. On palpation the uterine tumor gives in some places a firm feel, in others an elastic, and in others an obscure sense of fluctuation, or the fluctuation may be general, but always deep-seated and indistinct. The indescribable sensation conveyed by a colloid cyst is absent, being replaced by the elastic resistance given by the thick wall of the fibro-cyst. On tapping, the fluid from the latter source is thin and serous, containing comparatively little albumin, unless it is mixed with blood; its peculiar characteristic is its tendency to coagulate rapidly and firmly. The microscope reveals few elements except blood- and lymph-corpuscles, epithelial cells being absent. The existence of the "fibre-cell" of Atlee is questionable. The non-coagulability of ovarian cyst-fluid has already been mentioned.

If, as happens in the majority of cases, the abdominal cavity is opened, the exterior of a fibro-cyst appears of a dark, bluish hue, showing a firm fasciculated structure, and its vascular supply is seen to be unusually rich; an ovarian cyst, on the contrary, presents a pearly, glistening appearance, and is not particularly vascular. Palpation of the former cyst shows that it has a thick elastic wall, while the wall of the latter appears to be thin and membranous.

Distention of the Bladder.—A hyper-distended bladder has been tapped under the impression that it was an ovarian cyst. The subjective symptoms, the dribbling of urine which frequently attends this condition, the position of the tumor, and its rapid growth ought to render the diagnosis clear; the passage of a soft catheter will soon dispose of the tumor.

Tumors of the Omentum, etc.—Tumors in and behind the peritoneum, tumors of the omentum, etc., may be mistaken for ovarian cysts. Malignant disease is the most frequent condition. Reference has already been made to the symptoms. The rapid decline of the patient, the shooting pains, the rapidity with which ascitic fluid appears and re-accumulates after tapping—all point to the probable condition. Before, or after, tapping, the cancerous nodules in the omentum or peritoneum may often be plainly felt. Omental cysts are extremely liable to be taken for those of ovarian origin; indeed, in fluid removed from an undoubted cyst of the omentum I found numerous cells identical in appearance with those described by Drysdale. Encysted dropsy and abscess of the abdominal peritoneum are rare conditions, which have invariably an inflammatory history, while they do not cause general enlargement of the abdomen; fluctuation is obscure and circumscribed, and but a small quantity of fluid is obtained on tapping. There are no pelvic symptoms, and a vaginal examination gives negative results. I have known an adherent knuckle of intestine low down in the groin to be mistaken for an ovarian cyst; in fact, the true condition was not recognized at the abdominal section, but after death. Hydatid disease of the peritoneum is rare and is nearly always secondary to echinococcus of the liver. The differentiation from ovarian cysts is extremely difficult, as the so-called "hydatid thrill" is seldom well-marked. Under these circumstances, removal of a small quantity of the fluid for microscopical examination, will throw light on the diagnosis.

Tumors of the Intestine.—A. Fæcal Impaction. A large mass of fæces in the colon may simulate an ovarian tumor, since it may remain of undiminished size for months, although the patient affirms that her bowels are regular. There will be a history of colicky pains, gastric and intestinal disturbances, etc. The location of the tumor (in the colon, usually the transverse), its nodular and peculiar doughy feel, and its mobility, should awaken a suspicion of its true character. A vigorous course of treatment with cathartics and copious enemata will cause its disappearance.

B. Tympanites, Phantom Tumor, Pseudo-cyesis. This phenomenon is purely hysterical, as the history of the patient will usually show. The abdomen is generally distended and resonant, and the spine is arched forward in a peculiar manner, the recti muscles being kept extremely tense. No fluctuation can be obtained, no solid mass is to be felt, and on changing the patient's position no change will be noted in the percussion note. Her own statements regarding her symptoms are utterly unreliable. Obesity may be present as a complication, when the tympanitic resonance is obscured. Palpation in the latter case will give a general soft, doughy sensation, no deep-seated, globular tumor being felt. A valuable method is to seize the abdominal wall firmly and make a large "plait" in it, when its thickness can be accurately

estimated. The patient should always be anæsthetized, if possible, when the tumor will disappear, or the signs will change to such an extent that the true condition will be recognized. Spurious pregnancy (pseudo-cyesis) is described in all text-books on obstetrics and need not detain us here. The age, condition, and character of the patient (especially if she is sterile) and the state of the uterus and mammæ, will point to the true character of the affection.

Tumors of the Kidney. Solid tumors of the kidney, or the displaced organ itself, are occasionally mistaken for malignant or semi-solid ovarian growths of moderate size, but the same rule applies here as in every case of enlargement of one of the abdominal viscera, *i.e.*, the history shows that it began in the abdomen and grew downward, whereas the enlargement of the ovary proceeded from the pelvis upward. And moreover, the latter never becomes independent of the pelvic organs. A floating kidney, even after it has become enlarged or cystic, usually preserves its characteristic form, and can often be pushed back under the ribs. Cystic enlargement of the kidney (hydro- and pyo-nephrosis, cystic degeneration, and hydatid disease) is often difficult to distinguish from ovarian cyst. The points of difference in the history are important, especially the existence of calculus, hæmaturia, lumbar pain, etc. A renal cyst begins in the lumbar region and grows out from below the ribs, behind the intestines, the transverse colon intervening between it and the liver. An ovarian tumor lies in front of the intestines, except in those rare cases in which the gut has become adherent to its anterior surface. Examination of the fluid withdrawn from a renal cyst may, or may not, give positive results; we frequently find in addition to the albumin a quantity of urea and urates, which could only exist in a kidney-cyst, while the microscope shows pus, blood, pelvic and renal epithelium—evidence which, united to the history and the other facts, suffices to confirm the diagnosis. But in a large hydro-nephrotic tumor the smell, appearance, specific gravity, and chemical and microscopical character of the fluid may be quite misleading. The absence of ovarian cells and the comparatively small amount of albumin furnish negative evidence in favor of the cyst being of extra-pelvic origin. The urine in the case of the renal enlargement sometimes contains albumin and pus or blood, but it may be quite normal.

Enlargements of the spleen and liver hardly require more than brief mention. They both begin at the margin of the lower rib, the former on the left, the latter on the right side, their areas of dulness being continuous with those of the normal splenic and hepatic dulness, and separated from the pelvis by a resonant area, so that their independence of the latter is evident. They are depressed on deep inspiration. The edges of both tumors and the characteristic notch in the spleen can usually be felt. A careful history of the case, and an examination of the blood will aid, or serve to confirm, the diagnosis.

The reader must not infer from this brief *résumé* of the diagnosis of abdominal tumors that the character of an enlargement can be unerringly defined by applying the rules usually given. On the contrary, a large proportion of them are of a very obscure nature, and even explorative laparotomy does not always throw light upon doubtful points. The general tendency among laparotomists, at the present day, is to treat lightly the making of an exact diagnosis in these cases; explorative incision is, in their opinion, such a certain, and, at the same time, safe means of ascertaining the character of an abdominal tumor, that there is no reason why it should not be resorted to at once. It remains for the general practitioner to show the specialist that careful observation and the proper application of the rules of physical diagnosis may render the experimental use of the knife unnecessary, and (in cases of malignant disease, at least) may save the patient from incurring risks which are, in spite of our vaunted antisepsis, still considerable. Moreover, at the present day few operators like to report "incomplete" operations, and hence many explorative incisions culminate in rash attempts to remove tumors that ought never to have been touched, since a fatal termination in consequence of shock or hæmorrhage was practically a foregone conclusion.

Prognosis.—This varies with the character and rapidity of growth of the cyst and the occurrence of complications. A simple cyst gradually increases in size for two or three years without affecting the patient's health or causing any disturbance by reason of its size; it may then cease to enlarge, or it may suddenly begin to grow more rapidly. Rarely cysts exist for years without causing much disturbance or sapping the vital powers. The patient usually dies from exhaustion, aggravated by dyspnœa and venous obstruction, as well as gastric irritation. Or, being already enfeebled, she may be carried off by some intercurrent pulmonary or intestinal trouble. Death from cardiac paralysis is not unheard of; obstinate and uncontrollable vomiting may cause the fatal ending. Complete intestinal obstruction has been occasioned. Proliferous cysts grow rapidly, and terminate within a few months; malignant cysts tend to form secondary deposits, lead to ascites, and run a rapid course. Small intra-pelvic growths may become impacted, and cause inflammation and sloughing of the pelvic organs, while the serious consequences which follow labor under these circumstances are well known. It is a well-recognized fact that a certain class of ovarian cysts rapidly tend to become malignant, and since we have no means of determining positively before operation whether any given tumor is assuming, or may assume, this character, it follows that the prognosis is always doubtful; recent investigations have shown that parovarian cysts, that were formerly regarded as entirely innocent, are no exception to this rule, since they proliferate like the rest. Any one of the various complications previously described may result fatally. Localized peritonitis, due simply to friction, may become general, while rupture or suppuration of the cyst may cause death from peritonitis or septicæmia. Twisting of the pedicle, if it does not speedily lead to a fatal termination from hæmorrhage into the cyst and shock, is usually followed by sloughing of the sac and fatal peritonitis.

Does an ovarian cyst ever undergo spontaneous cure? The fluid is never absorbed so long as it is contained within the sac, and it is irrational to believe that the sac can ever undergo the retrograde changes which take place in an abscess-cavity, whereby the pus is absorbed and the cavity obliterated. As long as the cyst is freely supplied with blood through the pedicle, it tends to grow and to secrete fresh fluid from its walls. Should rupture take place and the fluid escape into the peritoneal cavity, in those rare cases in which the woman survives shock and peritonitis, the opening in the sac closes and the contents re-accumulate. Cases have been reported in which patients survived partial torsion or compression of the pedicle, and the circulation through the cyst was so far interrupted that it atrophied and even became completely detached. To summarize, there is no prospect of relief from an ovarian cyst except by surgical aid; ninety per cent. of the patients die within two years after first coming under observation, if not thus relieved.

Treatment.—This part of the subject may be dismissed in a few words. In the present condition of abdominal surgery an ovarian or parovarian cyst admits of but one form of treatment—ovariotomy. Tapping is now recognized as an unscientific procedure, which not only exposes a patient to the danger of peritonitis from the escape of fluid into the peritoneal cavity, or of hæmorrhage from the wounding of vessels in the cyst-wall, but also leads to no small risk of suppuration of the sac. A polycyst can never be completely emptied by tapping, and it rapidly refills, each operation proving a serious tax upon the patient's vital powers; in fact, the procedure, at first simple and without unpleasant after-effects, may, if frequently repeated, be followed by a serious reaction, so that it hardly seems as if the patient would survive it. But the most serious objection in the mind of the surgeon is that the effect of repeated tappings is to cause the formation of adhesions, that seriously complicate the radical operation, which sooner or later must be resorted to. There is good evidence that a proliferous cyst, if frequently

emptied, tends to assume a malignant character. In this connection it is well to caution the reader against accepting the general belief that a parovarian cyst, if once tapped, will disappear; on the contrary, such cysts often refill and undergo papillomatous degeneration. Probably a large ovarian cyst ought never to be tapped, unless the surgeon is prepared to open the abdomen, except during labor, when it is necessary to relieve the pressure at once (in cases of great dyspnœa, vascular obstruction, etc.), and when the patient is too weak to survive the radical operation, or where the sufferer herself desires to try the effect of tapping before submitting to ovariotomy. It is unnecessary to describe the operation, in which the aspirator is to be preferred to the trocar. A firmly adherent intra-pelvic cyst sometimes causes such pressure-symptoms that it is necessary to aspirate it through the vagina; to follow a strictly expectant plan would be to expose the patient to the danger of spontaneous rupture, with the usual fatal consequences. The cyst being so small that it could not be drained through the abdominal wall, there remains no other course but to remove its contents and to wash it out with an antiseptic solution, incising freely, and draining it if suppuration ensue. Noeggerath's plan of stitching the edges of the cyst in the vaginal wound has given good results. The sac closes by granulation.

The injection of iodine into cysts after tapping has been abandoned, not only on account of the doubtful results, but of the positive danger which attends this practice; moreover, many of the radical cures reported from this treatment were probably, as Dr. Goodell observes, obtained in cases of simple parovarian cysts where tapping alone might have been equally efficacious.

Electrolysis was at one time supposed to offer a simple and sure means of curing ovarian cysts, without risk to the patient. It is safe to say that it will never be regarded with favor except by a few enthusiasts. Ovariotomy is the only rational way of dealing with the disease, which was formerly regarded as incurable, but is now recognized as the most legitimate and hopeful subject for surgical interference.

Parovarian Cysts.—A brief allusion to these growths cannot well be omitted. They result from distention of one or more of the parovarian tubules, which are situated in the folds of the meso-salpinx; they are nearly always monolocular, are of slow growth, and frequently rupture spontaneously and do not refill. They are distinguished from ovarian cysts, first of all, by their situation between the folds of the broad ligament below the Fallopian tube, which passes over their upper surface, while the ovary is found attached to the cyst at a lower level. As Doran has shown, they sometimes contain papillary growths. They have a thin wall, lined with a single layer of columnar epithelium, often ciliated. The fluid is thin, colorless or opalescent, with a very low specific gravity (1.002 to 1.008), containing a trace of albumin and no paralbumin. Few cell-elements are found in it, except columnar epithelia. These cysts seldom cause either local or general disturbance, unless they develop papillary growths, a complication which has been observed after tapping. They seldom attain a large size, and are not subject to the accidents described as occurring in the case of ovarian cystomata, with the exception of rupture, which not infrequently takes place; the fluid being absolutely bland, no reaction follows. The cyst may refill, though slowly. Sweeping statements have been made to the effect that they never refill after having been emptied spontaneously or artificially, but Olshausen is, perhaps, not wrong in saying that, "on the whole, the number of radical cures without extirpation or excision of the cyst is certainly small."

The anatomical and clinical differences between these growths and cysts of the ovary are sufficiently evident. Their lateral position with regard to the uterus, their slow growth, the thinness of their walls, and the distinct wave of fluctuation obtained on palpation, point to their true character, while diagnostic puncture reveals their peculiar watery fluid.

Puncture has been universally recommended, but, in view of the possibility of an error in diagnosis, of the danger of recurrence of the cyst in a less benign form, and of the ease and safety with which it can be extirpated, the radical operation is to be preferred. However, the tumor is sometimes firmly adherent, and no pedicle can be found, so that it is necessary to enucleate it from the broad ligament. If this is impossible, I should feel safer to stitch the edges of the non-removable portion of the cyst into the wound and to drain it, rather than to leave the adherent part in the cavity without introducing a tube; the latter practice has often been adopted, however, with good results. *H. C. Coe.*

OVARIOTOMY. The method of performing ovariotomy has undergone many changes in the past twenty years, and is now much simpler and more uniform than it used to be. While it cannot be said that there is any standard or universally accepted operation, the differences are chiefly in details, many of them comparatively unimportant. No attempt will be made in these pages to describe all the methods of operating adopted by even the more eminent surgeons, but the operation will be treated of according to the writer's own experience, or that which has come under his observation, in a large number and variety of cases. Success in ovariotomy, whatever method be chosen, depends largely upon attention to details apparently insignificant in themselves, but in the aggregate often capable of determining the issue. This may be said of all operations, but it is especially true of those which involve the peritoneal cavity. The preparation of the patient, her surroundings, the operation itself, and the after-treatment, will be dealt with separately, and as concisely as the nature of the subject will admit.

The Rooms.—The room in which the operation is to be performed is to be selected with care, and likewise the room to be occupied by the patient afterward. Special attention should be given to the operating-room. In hospitals there is usually little difficulty in securing perfect cleanliness. In private practice personal attention must be given by the operator or his assistants to the thorough preparation of the room. It should be large, well lighted, well ventilated, as free as possible of furniture, having an open fireplace, and not having bath- or water-closets adjoining. Where all these conditions cannot be obtained, the lack may be somewhat counterbalanced by additional care and vigilance. In any case, the room is to be made perfectly clean and aseptic by every means available. If the walls and ceilings are painted they can easily be thoroughly washed, first with hot water, and afterward with warm water to which pure carbolic acid has been added in the proportion of two ounces to the gallon; or bichloride of mercury, one drachm to the gallon. The wood-work and all recesses and corners are to be cleaned in the same way. If the walls are papered they can be made tolerably free from dust by using a damp cloth and the antiseptics. The floor, if not very old, is better without a carpet, and should be thoroughly scrubbed; but if the carpet is new and clean it will suffice to have it entirely covered with new, clean, cotton cloth, which is tacked over it in every part of the room. After the final cleansing the windows should be closed, and the room is not to be disturbed until two or three hours before the operation. The use of carbolized spray, for at least one hour immediately before operating, is recommended as a means of precipitating the finer particles of dust; a five per cent. solution of carbolic acid may be used. The temperature of the room during the operation must not be allowed to fall below 75° F. Only such furniture as is necessary is to be put in the room, and it is better if not upholstered. In guarding against any possible danger from unwholesome surroundings, no detail, however small, is unimportant. All curtains are to be removed, and the blinds must be made perfectly clean. All sheets, towels, and gowns to be used during the operation should be soaked in the hot carbolic solution, dried rapidly, and put away until needed. The room to be occupied by the patient need not have the same care bestowed on it as the operating-room, but, of course, should be well purified. It should, if possible,

face the south and have plenty of light and an open fire; and it should be quiet. The means of supplying the necessary things for the patient and nurses should be thought of and arranged beforehand, so that there may be no knocking at doors and giving of orders just when it is most necessary for the patient to be kept asleep and entirely free from all annoyances.

Preparation of the Patient.—The patient should be carefully prepared for several days beforehand. The bowels should be thoroughly opened by means of gentle aperients, to ginning at least three days before the operation. Special pains must be taken to rid the bowels of any hardened fecal matter that may have accumulated, notwithstanding a regular daily movement. An active cathartic should never be given the night before operating, as it leaves the patient weak and depressed. It is well to give the patient only light and digestible food for a week or more before the operation. That food is best which, while sufficiently nourishing, leaves a small residue and does not tend to cause flatulence. The presence in the intestines of partially digested food of an irritating kind, or of a kind prone to fermentation, is a frequent cause of distressing tympanites after operation, and probably predisposes to the development of peritonitis. It is well, therefore, for the patient to abstain for several days from vegetables and from all but what is known from her own experience to be easy of digestion. In the case of those who suffer habitually from indigestion, it is well to prescribe a diet of milk and Vichy water or of koumiss for three or four days preceding operation. This is particularly desirable where the patient suffers much from the pressure of a large tumor, a condition often associated with very troublesome constipation. It is well in all cases to order a large enema of hot water, with two ounces of olive oil, to be given about twelve hours before operating. A light meal should be taken not less than five hours before the time of operating, and nothing whatever in the interval. The latter rule is very hard to enforce, and almost impossible if the friends of the patient are allowed to advise. The patient should be in the open air as much as possible; she should take a warm bath at bedtime, and keep the skin active by massage, or by friction with a coarse towel. The urine should be carefully examined and the quantity ascertained. The presence of albumen in any amount is a warning to be very careful in the use of anæsthetics. The mental condition of the patient is not to be lost sight of. The surroundings must be made as cheerful as possible, and those immediately around her should avoid the discussion of surgical questions, and keep her mind engaged with more cheerful topics. If she is sleepless, some light food may be given before bedtime, and if necessary, the bromides, with or without chloral, in small doses. Opiates are to be avoided, if possible, but if the patient is to any extent accustomed to their use, it will be better to continue the usual drug than to allow her to become restless and uncomfortable for want of it. She should not be allowed to see or hear anything of the preparations, and should on no account be permitted to go into the operating-room, being carried there only after she has been brought under the influence of the anæsthetic. A hot bath, and after it a good rubbing, should be given the night before the operation. It is a bad thing for most patients to have a long interval of suspense between the time when an operation is decided on and the time of its performance.

The Operator and Assistants.—The operator and his assistants and nurses must be absolutely clean and aseptic, to insure the greatest safety to the patient. The rules of cleanliness apply to all who are to take any part in the operation. Care should also be taken that no spectators are present who have taken part recently in dissections or *post mortems*, or who have been in contact with cases of contagious disease of any kind. The smaller the number of spectators the better. In the ideal operation no one would be present who is not absolutely necessary. If the operation must be performed in the presence of spectators of doubtful surgical purity, the use of the spray, directed between the spectators and the patient, is a valuable precaution.

Thorough cleansing of the hands of the operator and his assistant is a very important part of the preparation. The hands and arms should first be well scrubbed with hot water and soap, by means of a *new* nail-brush; they should then be cleansed again in plain hot water, using the nail brush thoroughly, and as a final washing they should be soaked, the nail brush being again used, for three or four minutes in a bichloride solution, one to one thousand. If anything septic has been handled recently, additional precautions are necessary, especially in cleansing the hands. Clean gowns should be worn, covering all the clothing, and leaving the arms exposed up to the elbows. These gowns should be of linen or some material that can be washed and disinfected easily. The rubber cloth gowns and aprons sometimes worn in hospitals are particularly objectionable, because of the difficulty of cleansing them. It would doubtless add to the cleanliness of the operation and the safety of the patient if all who are present in any capacity were compelled to wear clean gowns over all the other clothing. To all these matters of preparation, especially as to antiseptics, the operator will do wisely to give some personal attention, as he is less likely than others to be influenced by the scepticism of those who carry out directions in a half-hearted way, and who often ridicule the attention given to details supposed to be petty or fanciful.

Instruments Necessary.—The instruments actually necessary in an uncomplicated case of ovariotomy are very few; but as complications may arise, and unforeseen difficulties may present themselves, and as there is an element of uncertainty underlying every case before operation, it is well to be provided with everything necessary for an emergency. It is annoying to the operator to be cumbered with rows of unnecessary instruments, among which he or his assistant has to search hurriedly for what he needs; it is also embarrassing to want some very useful instrument and find it has been left behind; it is well, therefore, to have many instruments in reserve, and to have those which are indispensable arranged in trays by themselves, within easy reach. If the operator is so fortunate as to have an assistant who knows and can anticipate his wants, and who is familiar with his instruments, the latter may be intrusted to that assistant; if not, the instruments had better be placed where the operator can easily reach them himself. The following instruments are almost indispensable to most operators, and will be found sufficient for non-complicated cases: One scalpel, one director, two retractors, one pair of scissors, twelve pairs of pressure-forceps, two pairs of long-handled pressure-forceps, one trocar of medium size, either curved or straight, one No. 6 male sound, two small tenacula, one strong hook or large tenaculum, two Nélaton's forceps, one needle-holder, one sponge-forceps, needles of various sizes with round and triangular points (the latter for the abdominal walls), glass drainage-tubes of different sizes, artery-forceps, ether-inhaler, spray apparatus, a soft-rubber catheter, and a small rectum-tube.

Besides these instruments it is necessary to have one dozen hand sponges, three or more flat sponges, one dozen small sponges for the abdominal cavity, to be used in the forceps, silver wire No. 27, silk and catgut of various sizes, fine Chinese silk for possible wounds of the intestine, rubber adhesive plaster, iodoform and iodoform-gauze, pure carbolic acid, tablets of bichloride of mercury, and trays for instruments.

The following instruments should be held in reserve: Paquelin's cautery, portable electric light, vulsellum-forceps, clamps for seizing the pedicle in case it should be unusually large, Koeberle's wire écraseur, elastic ligatures, Davidson's syringe, one large Thomas clamp, long needles for transfixing the pedicle, Sims' plate for supporting them, small aspirator, faradic battery, large hypodermic syringe. The coil for ice-water can be procured later if required.

The nurse who is to have charge of the case should be charged to have the following in readiness: Three basins, two or three new wooden pails, nursery lamp and alcohol, three abdominal binders made of unbleached muslin—not flannel—rubber cloth, hot-water bag, nail-brush, boil-

ing water in quantity, bottles for hot water, operating-table, properly covered; several small sheets and a small blanket, safety-pins, absorbent cotton, thin ice-bag for the head, mustard leaves, lime-water or Vichy, measuring-glass, thermometer for the room, vaseline, bed-pan, Davidson's syringe, opium suppositories, and brandy or whiskey. The nurse is responsible also for arrangements as to the supply of ice, milk, etc., for the patient after operation.

The completeness of the preparations made for the care of the patient after operation may depend somewhat on whether there is in the vicinity a druggist from whom certain things can be obtained promptly as required.

During the operation the instruments to be used must be kept in a tray or shallow dish, and covered with hot water; if distilled water, or water which is boiled, is used for this purpose, it is not necessary to add carbolic acid; the bichloride solution should never be used for the instruments. The sponges are to be kept in a five per cent. carbolic solution, and should be handled as little as possible. The sponges for the abdominal cavity must be kept in a hot bichloride solution, $\frac{1}{2000}$. All the towels used during the operation are to be prepared, as before-mentioned, by boiling them in a carbolic solution, and afterward drying them, after which they are folded up and not handled until the time of the operation. All water used should be either distilled water or water that has been boiled; if water can be obtained from the boiler of an engine, it is to be preferred, as the temperature of such water is raised far above the boiling point, and any germs it may contain are more certainly destroyed.

Anæsthetics.—In this country ether is considered the best and safest anæsthetic, but it is particularly necessary in abdominal operations that it should be administered with care. It may be given by means of a towel or sponge, or by means of some form of inhaler. Alliss' inhaler, carefully used, answers better than the cone. For the past two years the writer has used Clover's inhaler with much satisfaction. Its use requires more skill than that of other inhalers, but if properly managed the patient suffers less depression, takes less ether, and is less liable to subsequent vomiting or nausea. This inhaler allows the assistant using it to regulate exactly the proportion of ether-vapor and air inhaled. It is well to begin with one-fourth part ether, and when the patient is unconscious to increase it to one-half. In skilful hands this inhaler may be used for an hour with a quantity of ether varying from one to two ounces. Those unaccustomed to the use of Clover's inhaler are generally prejudiced against it. It is somewhat complicated and expensive, but it has advantages over any other. In any case the anæsthetic should be given in a quiet room, and there should be no one present who is not absolutely required. The patient should be so prepared and reassured beforehand that she will not be liable to resist its administration. If her co-operation can be obtained, anæsthesia may be produced in from three to five minutes; if, on the other hand, the patient is frightened, and the inhaler is frequently removed to gratify her desire to take the ether gradually, excitement is almost sure to follow, and it will require a much longer time to render her unconscious. In capital operations, like ovariotomy, ether should always be given by an experienced hand, as nothing is more embarrassing to the operator than to have the anæsthetic given interruptedly. It should be so administered that the operator's attention to it is not required from first to last. It is better, as a rule, to give the ether upon a bed or lounge, and transfer the patient afterward to the table; it is also important that she should see and hear as little as possible of the preparations. Before giving ether, or any anæsthetic, the urine should always be carefully examined. The presence of a small amount of albumen may be due to the pressure of a tumor, and in that case will disappear after its removal. If there are also casts, or other indications of renal disease, there is danger in the administration of ether. The condition of the heart and lungs should also be ascertained; and the existence of bronchitis should never be overlooked, as it is a condition which may give rise to much trouble under ether. The habits of the patient as to stimulants, opium, or other narcotics should be taken into account. A certain amount of danger attends the administration of ether, even under the most favorable circumstances, and it is well to provide against accidents. A faradic battery should always be in readiness for instant use should the patient's respiration fail. Facilities for applying heat by means of rubber bags or bottles should always be at hand during an operation.

The Operation.—The patient should be placed upon a table about two feet in width and long enough to support the feet; it is sometimes better to allow the feet to rest upon a pillow or chair, the legs being flexed at the knees; the shoulders and arms should be protected by a loose flannel wrapper, and the lower limbs enveloped in a blanket; it is well to protect the hands and arms by pinning a towel around them, and if they are placed gently under the patient's back, they will be entirely out of the way. The abdomen should then be again thoroughly washed, first with soap and water, and afterward sponged with an antiseptic solution. During this procedure the upper hair on the pubes should be carefully shaved. A towel, wrung out of a hot antiseptic solution, should be placed above and below the exposed portion of the abdomen to prevent contact with clothing or blankets. The operator stands on the patient's right and his assistant directly opposite; the second assistant takes charge of the instruments, and is also stationed opposite the operator, but nearer the patient's feet. The sponges and antiseptic solutions are placed in charge of two competent nurses, who may or may not be superintended by a third assistant. The assistant who gives ether should take no other part whatever in the operation, and should be blind to all else that is going on. The number of assistants required depends somewhat on their experience and their acquaintance with the methods of the operator; they should always be assigned to their places and work before the operation begins. There should be no talking among the assistants, operators, nurses, or spectators.

A small incision should be made first, beginning about two inches below the umbilicus, and extending downward from two to three inches in the median line; this incision may be carried directly down to the fascia of the recti muscles. The bleeding points, if any, are seized with pressure-forceps, which may be left attached for the time. The fascia is next cut through, and the recti muscles separated without cutting. In many cases a stratum of fat is now met with, lying directly on the peritoneum. This fat is cut through, or pushed to one side, when the peritoneum is exposed. A pause is now made to examine the wound and arrest all bleeding. The peritoneum is then seized with a fine tenaculum or with the forceps, raised, and cautiously opened with scissors or knife. The opening thus made is enlarged by cutting on the director or finger upward and downward. The shining surface of the cyst now appears. The patient is now turned on the side next to the operator, and a straight trocar, protected by sponges, is plunged into the cyst; as soon as the cyst-wall is sufficiently relaxed it is seized by a large hook and drawn outward through the wound; the hook is then replaced by Nélaton's forceps, one pair of which should be above and one below the trocar. As the collapsed sac extrudes, pressure is kept up upon the abdominal walls by the hands of the assistant, and the opening made with the trocar is enlarged by scissors so as to speedily empty the cyst of its contents. If a part only of the cyst is evacuated, the hand should be introduced to break up other cysts and evacuate their contents. The hand at the same time will appreciate the bearings and attachments of the cyst and the position of the pedicle. As soon as the cyst has been emptied the patient is replaced on the back, the wound being carefully protected by hot towels or flat sponges. The pedicle is now transfixed by a round-pointed needle carrying a double ligature of catgut or heavy silk; this ligature is then cut, and the separated halves are crossed and tied; the first half having been tied with a double knot, is cut off short; the second half is then tied in the same manner; but before cutting it off it is brought back, made to embrace the

whole pedicle, firmly tied, and cut short. Before separating the tumor, the pedicle is held up about the level of the wound by a strong tenaculum, in order that it may be examined thoroughly before it is dropped back. If no adhesions have been separated, and if there is no bleeding from other sources, very little sponging is required, and the less the better. The wound is closed, if small, in the manner adopted by the writer several years ago, and now generally followed. One silver wire is passed through the entire abdominal wall, including the peritoneum, entering on the side next the operator, and emerging on the opposite side. This wire is left loose until the rest of the operation is completed. The next step is to pick up the peritoneal edges and sew them carefully together by a continuous suture of catgut, using what is known as the lock-stitch. The peritoneal cavity is now shut off securely. If the fascia can be easily brought together as a separate layer, that may also be closed by catgut; the remainder of the wound is then closed by sutures of silver wire or silk, carried through the skin and adjacent tissues, down to the fascia. As these sutures are twisted or tied, the first suture is also brought up and twisted. The effect of the first wire is to keep the peritoneum in contact with the structures immediately above it. The needles used in closing the abdominal wound are of two kinds: that for the peritoneum is straight and round-pointed; that used for the fascia and for the rest of the abdominal wall is straight, and has a triangular cutting point. The abdominal wound may be closed with silver wire, with silk, or with catgut. Silver is less likely to be followed by abscesses in the line of the suture, and by its rigidity it keeps the edges of the wound more perfectly in contact than do the softer sutures.

The method of operating above described is subject to many variations, according to the requirements of the case. The method of dealing with adhesions and with hæmorrhage will be described elsewhere.

If, however, the adhesions are so extensive that the removal of the tumor is impossible, enucleation of the sac may be tried. The capsule of the sac is opened and stripped off in its whole extent. This is a valuable resource in a certain class of cases where removal otherwise would be impossible. Or a portion of the sac may be drawn out and cut off, while the remaining portion is secured in the abdominal wound, and drained by a tube. It is important in such cases to close the peritoneum entirely, so that none of the contents of the cyst can find their way into the abdominal cavity. These sacs may be drained very conveniently by means of the curved hard-rubber drainage-tube, devised by Dr. H. Marion Sims. In this tube the water enters by a small opening, and is discharged freely by a large one; the cavities of cysts thus drained generally fill up rapidly from the bottom, and give very little trouble during the process of healing.

In cases in which, from the separations of adhesions, or from any other cause, there is reason to apprehend hæmorrhage, or considerable oozing in the deeper parts, great protection is afforded by the use of a small, straight, glass drainage-tube, carried to the lowest portion of the pelvic cavity, where the blood necessarily gravitates. This tube may readily be examined from time to time, using for the purpose a piece of soft rubber tubing, a little longer than the glass tube. This is introduced open, and carried to the bottom of the drainage-tube, when it is pinched and withdrawn, bringing with it whatever blood or other fluid may have accumulated in the tube. The glass tube is left in place twenty-four or forty-eight hours, according to the indications. It may generally be removed twenty-four hours after the operation. By means of this tube, frequently examined, early indication is given of hæmorrhage which might otherwise prove serious even before it was suspected. The sutures having been twisted and cut off short, are bent so as to lie flat upon the surface, the wound is dusted with iodoform, and covered with a narrow strip of iodoform gauze; over this strips of rubber adhesive plaster are applied. Over all is placed a layer of absorbent cotton, and a firm abdominal binder is added. The patient is then placed in bed, preferably in some other room than the one in which the operation has been done.

There is a great difference between the operation for the removal of a large ovarian tumor, and that for the removal of small cystic ovaries. In the former case the abdominal wall is often very thin, and little can be recognized but the integument and peritoneum; in the latter case the walls are undisturbed, and there is often a very deep layer of fat, so that difficulty may be experienced in finding the peritoneum. In all cases it is of the utmost importance to close the abdominal walls, layer by layer if possible, carefully and accurately. The neglect of this part of the operation is often followed by imperfect union, leading in time to ventral hernia. The method of closing the wound, when it is necessary to introduce and leave a drainage-tube, is described elsewhere.

The after-treatment of cases of ovariotomy will be more appropriately given after some account of what is known as "Tait's operation"—the removal of the tubes and ovaries.

Removal of Ovaries and Tubes: Tait's Operation.—This operation differs from that for the removal of an ovarian tumor. It is more difficult to perform, and there is fully as much uncertainty as to what will be discovered after making the incision. The operator may find merely a cystic ovary, perfectly free, and easily drawn out of the wound. He may, however, find the ovary, or ovaries, with the tubes, so firmly bound down by adhesions that the operation will have to be abandoned.

The patient is submitted to the same preparatory treatment as for ovariotomy. The first incision should not exceed two inches in length. Much care is necessary in making the incision, as the abdominal walls have generally their normal amount of fatty tissue, and the muscles and fascia are not thinned or atrophied, as is generally the case when they have been subjected to the pressure of a tumor. The peritoneum, being in contact with the intestines or omentum, must be divided with special care. The incision having been completed, two fingers are introduced and the pelvic region is explored. If the diseased ovary is detected, it is cautiously raised and inspected. The abdominal walls being at the same time depressed by an assistant, the ovary and its accompanying tube are then held between the fingers of the operator's left hand, and the pedicle is tied by catgut or silk, as in ovariotomy. Before proceeding to the ovary on the other side, it is well to be assured, by the passage of a small sponge, that there is no bleeding from vessels which may have been torn by traction on the ovary that has been removed. The ovary and tubes on the side opposite are now examined by the touch, and, if diseased, are removed in the same manner as the first. If there is no bleeding the wound may be closed at once, by passing through the entire thickness of the abdominal wall two or three silver sutures, in which the peritoneum is carefully included. Perfect union of the peritoneum and other structures composing the abdominal wall is more easily obtained in these operations than when the wall has been atrophied by pressure. It is a good plan, nevertheless, especially if the wound exceeds two inches in length, to close the peritoneum separately, by catgut, and afterward the fascia. In some cases this is more easily done than in others, so that no absolute rule can be laid down applicable to every operation. If the abdominal wall is thick, and the peritoneum hard to reach, it is better not to waste time in endeavoring to draw it up and close it separately; it is very important, however, that it should be included in the sutures. The subsequent dressing and treatment of the wound are precisely the same as in ovariotomy.

The principal dangers in this operation are two: First, that of making sufficient traction on the broad ligament to rupture its vessels; second, that of cutting off the pedicle too close to the ligature, which may subsequently allow the tissues to retract, and thus escape its grasp. The first danger is avoided by making only very gentle traction, and by depression of the abdominal walls; the second, by leaving the cut end of the pedicle rather longer

than it should be, and cautiously trimming it if necessary. If, in examining the cut surface, a divided artery is seen, it is well to tie it separately with catgut, or to apply the cautery to it, and to the whole surface.

If, on passing the fingers down in the first exploration, the ovary and tube are found to be bound down by adhesions, the character of the operation is entirely changed. If the adhesions are of recent origin they may give way easily on pressure with the finger, and the mass to be removed can be gradually loosened. There is apt to be some hæmorrhage during this process, of which frequent gentle sponging will keep the operator informed. If the adhesions are too firm to be separated thus, and the amount of disease renders the operation imperative, the incision is at once enlarged enough to admit the hand of the operator; the intestines can then be pressed upward and a good view of the deep parts obtained. Here it is that the electric light may prove of great service. As the adhesions are separated, any bleeding points are seized by the forceps and tied with catgut. It is in these cases that we often have to deal with a tube distended with pus, perhaps to the point of bursting, and the most delicate manipulation is necessary to avoid the accident. In desperately bad cases the tube may rupture, and the operator may not be able to remove it. The abdominal cavity must then be thoroughly irrigated, every vestige of pus removed, and, if possible, the pus-secreting cavity cut off from the abdominal cavity by stitching in it the wound. If everything can be removed, the consequent hæmorrhage is to be controlled by tying all bleeding points which are exposed, and by pressure with a nearly dry sponge upon those which cannot be tied. Pressure with a sponge which has been dipped in the powdered subsulphate of iron may be used as a last resort; here also a firm vaginal tampon will often be of great assistance. If by means of retractors and the electric light any bleeding points or oozing surfaces can be distinctly made out, they may be touched by Paquelin's cautery. A glass drainage-tube of proper length is adjusted in the lower angle of the wound, which is then closed in the usual way. The tube should be of such a length as to reach the lowest point in the pelvic cavity, and not to project much above the wound. Before applying the dressings the tube is examined by passing to the bottom of it a piece of soft rubber tubing, open at both ends. The outer end is compressed by the fingers, and the tube withdrawn; if there is very little bleeding, the tube is closed by a plug of iodoform gauze, and the usual dressings applied, care being taken not to cover the end of the tube with the plaster; the tube may then be easily examined, without disturbing the patient, every hour or oftener, for some time after the operation, or until the danger of bleeding has ceased. Should there be sufficient hæmorrhage to warrant it, the operator has only one course before him, which is to reopen the wound and search for and secure the bleeding vessels; if, on examining the tube at hourly intervals, the amount of blood is found not to exceed more than one or two drachms, there is no danger in waiting. If the blood removed is dark, it will gradually become less in quantity; if red or unmixed with serum, there is more need of vigilance. Before opening the wound recourse may be had to hot water, two ounces or more being introduced through the tube and allowed to remain. Styptics, as alum, ferric alum, or even iron, may be tried, according to the judgment of the operator. The danger of hæmorrhage from torn adhesions is generally very slight after twenty-four hours; but danger from the torn vessels in the broad ligament, or from the pedicle has not the same limit. Common to this operation and to ovariotomy are the following:

Accidents and Complications.—Among the accidents that may occur are hæmorrhage, wounds of the abdominal viscera, as of a loop of adherent intestine, the escape of pus or other septic fluid into the peritoneal cavity, and collapse, in consequence of either shock or hæmorrhage.

1. *Hæmorrhage.* The cause of bleeding is often the separation of adhesions, especially those which are deep-seated in the pelvis, where it is difficult to obtain a perfect view. This form of hæmorrhage is particularly troublesome before the tumor has been completely removed and the pedicle tied. If arterial, the bleeding points are seized with forceps and tied with catgut or silk. When it is impossible to tie them, the forceps may be left temporarily attached, and the operation proceeded with. If the hæmorrhage is venous, firm pressure with sponges will generally suffice to control it. Intestinal adhesions which can be safely separated do not generally give much trouble, but the omentum often contains large vessels which need to be tied before the operation is completed. It is sometimes necessary to tie a portion of omentum close to the tumor in two places and cut between the ligatures, leaving a small portion attached. Where a large portion of omentum has been separated, it should be turned out and thoroughly examined before dropping it back, as small bleeding points may otherwise be overlooked. What blood escapes generally gravitates into Douglas's pouch, and may be discovered there by sponging. If after sponging it reaccumulates there, free search must be made for its source. A cause of hæmorrhage to which little attention has been directed is the tearing of the broad ligament during traction on the pedicle in the removal of small tumors or of the ovaries and appendages. This seldom occurs in the removal of large tumors, because the ligaments have been stretched or relaxed by long-continued traction and pressure. In some cases a very slight amount of traction on the broad ligament is sufficient to give rise to serious hæmorrhage below the pedicle. Hæmorrhage from this cause often makes it necessary to enlarge the wound in order to reach and tie the torn vessel. Hæmorrhage sometimes occurs from tying a soft pedicle too tightly with a harsh ligature, which cuts through the more delicate tissues and allows them to retract. Hæmorrhage from this cause, and from that last mentioned, is particularly dangerous, because not liable to be detected before the pedicle is dropped back. If there is evidence of considerable bleeding, the wound should be immediately enlarged, and the intestines, protected by hot towels or flat sponges, should be drawn upward so as to expose the pelvic cavity. If the ovarian artery is the source of hæmorrhage it should be tied separately. If the bleeding point cannot be seized and tied, Paquelin's cautery may be used with advantage. In this emergency the electric light is often of much value. Other means failing, the mass of bleeding tissue may be seized in one or two pairs of long compression forceps, which may be left in place for twenty-four hours or longer without danger. The writer has often employed a firm vaginal tampon as a hæmostatic in case of oozing from the deeper parts of the pelvis. Bearing in mind the danger of wounding the broad ligament by traction, it is better not to raise the ovaries and appendages above the abdominal surface if any effort is required to do so. The ligature must be passed below the ovary, care being necessary not to tie too close to the uterus. Traction is often made, almost unconsciously, by the assistant, while the operator is tying the knot. General oozing from the parietal peritoneum, after the removal of a large adherent tumor, is sometimes very troublesome. Pressure with a nearly dry sponge is often useful, and, if necessary, may be rendered more efficient by the use on the sponge of a little finely powdered subsulphate of iron. Another means which may be safely tried is the use of very hot water poured freely into the abdominal cavity and removed with sponges after a few minutes. In very obstinate cases the writer has checked parietal hæmorrhage by pinching up a large fold of the abdominal wall from without, and passing a silver wire through the folds so as to include the entire mass in a loop of wire, which wire may be allowed to remain for twenty-four hours. In all cases in which there has been much oozing during the operation, the writer is accustomed to use a small, straight, glass drainage-tube, one end of which rests in Douglas's pouch, while the other, having a small flange, is secured in the lower angle of the wound. An examination of this tube, by means of a piece of soft rubber tube passed to the bottom of it, as before mentioned, and pinched and withdrawn, will

furnish information as to the amount of blood in the cavity and enable the surgeon to detect hæmorrhage before it has advanced so far as to endanger the patient's life. The glass tube should be inspected every hour at first, and should be gently raised each time to make sure that any surrounding blood does not escape detection. If the bleeding is insignificant the tube may be removed after twenty-four hours. By means of this tube the surgeon not only learns what is going on in the pelvic cavity, but is able to apply remedies, as hot water, iron, etc., with very little disturbance to the patient. If the precaution is taken during the operation to pass a suture of silk or wire through the abdominal wall, directly across the track to be occupied by the tube, its ends being left loose, the wound may be brought together, when the tube is removed, with the greatest facility, and without causing the patient any pain.

2. *Escape of Septic Fluid into the Cavity.* The fluid from some ovarian cysts, and from most parovarian cysts, is innocuous. On the other hand, the fluid from many ovarian cysts is extremely irritating and septic, and gives rise to peritonitis. This is true of the so-called colloid fluid, which is not only hard to remove, but generally very irritating. In cases of pyo-salpinx the fluid is often fetid pus, and is particularly dangerous. In all cases of abdominal tumor escape of the contents of the tumor into the abdominal cavity should be prevented if possible. If the cyst is large, the patient should be turned upon her side before the contents are evacuated.

If by any accident, as will sometimes happen, fluid, supposed to be harmful, has escaped into the abdominal cavity, it must be carefully removed by sponging. If it should be pus or other offensive fluid, not only should the abdominal cavity be gently and thoroughly sponged, but it should be washed out freely by warm carbolized water until the water comes out clear. Sponging alone will not render the cavity sufficiently clean. Davidson's syringe may be used for irrigation, but it is even better to pour the water in boldly from a pitcher, and get rid of it by turning the patient on the side, or by sponging. For irrigation only boiled water should be used, and it should contain one and one-half per cent. of pure carbolic acid. In some cases there is not only an escape of pus, but a portion of the pyogenic surface of the cyst or tube may remain, in consequence of adhesions. In such cases additional care is necessary in cleansing the cavity. In all cases in which pus or any suspicious fluid has come in contact with the peritoneum the drainage-tube should be used, as it affords a means of irrigation in case of septic trouble. The escape of blood into the peritoneal cavity is not necessarily dangerous. A small quantity of blood may remain in the peritoneal cavity without causing any disturbance, but it should be the aim of the operator, before closing the wound, whether a tube be used or not, to leave the cavity as clean as possible.

3. *Collapse.* The liability of patients to collapse varies greatly even under the same conditions. An operation which lasts an hour is more likely to be followed by collapse than one which is completed in fifteen or twenty minutes. The sudden removal of a very large tumor may cause collapse, but it more often follows the separation of firm or extensive adhesions, especially those involving the intestines. The loss of blood is also a determining cause of collapse. A long incision, and the exposure of the intestines for any length of time, is liable to be followed by extreme depression, especially if the air of the operating-room is not pure and sufficiently warm; for this reason the use of the spray is objectionable where the operation involves much exposure. The influence of the anæsthetic in causing collapse will be considered elsewhere. It is important in all cases that a patient should not be allowed to become cold; the hands and feet should be well protected, and the abdominal walls should be, as far as possible, covered with hot towels or flat sponges, upon which hot water may be poured from time to time as they become cold. Hot applications over the head, and the free hypodermatic use of brandy are the chief remedies.

Complications.—These arise chiefly from adhesions, and as it is impossible to determine the existence and extent of the adhesions before operating, it is well to be prepared for anything. Vascular adhesions must, if possible, be tied before being divided. Adhesions which are not very vascular may usually be separated by means of a sponge, or by the hand, but it is never safe to separate them by traction, for fear of wounding the intestines and other delicate structures. If the cyst-wall is quite thin a very little manipulation will cause its rupture. Special care is necessary in the removal of small tumors which occupy the lowest part of the pelvis; in such cases it is difficult to appreciate the adhesions which may serve to attach the tumor to the uterus, bladder, or other organs. Adhesions to the uterus, however slight, are apt to bleed, and the bleeding is not easily controlled.

After-treatment.—During the first week the patient is kept very quiet and is not allowed to make any exertion; if there is much pain morphine is administered hypodermatically. For the first twelve hours after the operation no food whatever should be given, and as little water as possible. Cracked ice in small quantities may be given cautiously, but even that may provoke nausea; after twelve hours, milk and lime-water, or koumiss, may be tried in very small doses. It is best to begin with a teaspoonful, and gradually increase the quantity as the stomach will bear it. Rectal alimentation is necessary only in those cases in which the stomach persistently rejects food. Stimulants are necessary only in exceptional cases. If the operation has been a long one, or if there has been much hæmorrhage and the patient is exhausted, stimulants may be given by the rectum. When for several days the stomach persistently refuses food, systematic rectal alimentation must be resorted to. In other cases moderate amounts of liquid food, preferably milk or some of its preparations, should be the chief reliance for the first week. Some patients take peptonized milk well. There is nothing better, if it is not distasteful. If the patient is able to pass water without the use of the catheter she should be encouraged to do so. If it is necessary to use a catheter, a new one of soft rubber, about No. 6, should be chosen. The temperature need not be taken for eight or ten hours after the operation. There is generally a rise of temperature during the first twenty-four hours, perhaps from reaction. This soon subsides. The bowels should be moved, not later than the third day, by some simple aperient or by an enema. If there is distention of the abdomen within the first forty-eight hours it is well to give half-drachm doses of sulphate of magnesia, or quarter-grain doses of calomel, every two hours till the bowels move. The use of the rectum-tube will often relieve the distention. Another means of getting rid of the gases, which cause so much distress, is the use of injections into the rectum of half an ounce of oil of turpentine with olive-oil and soapsuds. It is well to turn the patient gently on the side before passing the rectum-tube.

The wound is not to be disturbed until the eighth day, unless pain is complained of. The wound should then be examined, and if there is evidence of the formation of an abscess means should be taken to give the pus free exit. It commonly happens that such mural abscesses open and discharge without interference. Sometimes, on removing the sutures, pus escapes in their track. Gentle pressure and frequent dressing will keep the wound clean and hasten the healing process. Iodoform should be used freely. The beginning of a mural abscess is often signalized by a sudden rise of temperature.

During the second week the diet is increased and some solid food may be taken. During the third week the patient, if all is well, may be moved on a sofa, and may even sit up in an easy-chair for a little while. At this stage of convalescence, especially if there have been no drawbacks, the patient is apt to attempt too much, or tire herself by talking to visitors. It is a good rule to allow no one to enter the room except the physician and the nurse for the first week, provided the patient is doing well.

Dangers after Operation.—The chief dangers are of shock, of hæmorrhage, of peritonitis, and of septicæmia.

In cases of shock the patient must be well supplied with artificial heat, by means of hot water in bottles, and of hot-water bags. A bag of hot water placed directly over the heart is a powerful stimulant. Brandy may be given hypodermatically, a fluid drachm at a time, and repeated according to the indications. The faradic battery is sometimes of service. Sinapisms over the epigastrium are also useful. If the patient can swallow, brandy may be given by the mouth. If not, it may be given, with strong coffee, by the rectum.

Hæmorrhage is another danger. It is often indicated by a fall of the temperature below the normal point, by a feeling of faintness, by cold perspiration, and a white or ashy complexion. If the indications are sufficiently alarming, no time should be lost in opening the wound and searching for the bleeding points. As the necessity for such interference generally arises in the night, or when it is difficult to get help, it is wise to make some preparation as to instruments, help, etc., so that no time may be lost. The treatment is precisely the same as in hæmorrhage after any other operation. If the patient has lost much blood, the advisability of transfusion of blood, or, better still, of the intravenous use of a saline solution, should be considered.

Peritonitis is much dreaded after any operation that involves the peritoneal cavity. It usually develops early, often within twenty-four hours. It is generally indicated by a rise of temperature to 102° or 103°, by an extremely rapid pulse, by intense pain in the abdomen, and by tympanites. Some or all of these symptoms may be absent. The patient should be kept free from pain by hypodermic injections of morphine; the ice-water rubber coil should be placed over the abdomen; the knees should be raised and supported on a pillow. An effort should be made to get rid of the gas that distends the abdomen. A large-sized male catheter may be introduced gently into the rectum, the patient being cautiously placed on one side. The ice-cap will relieve headache, if that is a distressing symptom. There is no objection, at the very outset of peritonitis, in giving some aperient medicine, unless the bowels have been so well moved before as not to need it. Antipyrin should be given, when the temperature is above 100°, in fifteen-grain doses every three hours, or more frequently if the temperature does not fall. Cold sponging is grateful to the patient, and does good. The stomach will not usually bear food, and it is better to allow it absolute rest, giving only a little cracked ice to allay thirst.

Septicæmia is another of the dreaded consequences of abdominal operations. It is shown by a temperature often rather persistently elevated than very high. It may fluctuate, but never falls to the normal point. There are chills, and there is a clammy moisture about the skin, entirely unlike the dry heat of peritonitis. Here the use of antipyrin is not indicated. Quininè and stimulants are the main reliance, together with systematic nourishment by the rectum. If there is any suspicion of an abscess the wound should be opened and the pelvic cavity explored. If any encysted collections of pus are found they must be broken up, and the cavity irrigated with hot carbolized water.

General Considerations.—All abdominal operations should be done as expeditiously as the circumstances will permit. The longer the peritoneal cavity is exposed the greater is the danger, both of shock and of peritonitis. Draughts of cold air, while the wound is open, are to be carefully avoided. Much time may be saved by having everything in perfect readiness beforehand. The operator should decide and act promptly in emergencies. There should not be the least haste, but there should be no avoidable delay. Silence should be enjoined on the spectators, and there should be no unnecessary talking among assistants or nurses.

The use of the spray is open to question. If allowed to play directly on the patient it cools the air, and to some extent obstructs the view. As a means of purifying the air, especially when other means of disinfection cannot be perfectly carried out, it seems to the writer to be a valuable resource.

There is a great difference among operators as to the length of the abdominal incision. No rule can be laid down applicable to all cases, but a short incision is better, *per se*, than a long one. If all that is desired can be as safely and as expeditiously accomplished by making a small opening, then it is to be preferred. Therefore it is well to begin with the short incision and enlarge it, if necessary, except, of course, in cases of large solid tumors. The successful performance of the operation should include a consideration of the future welfare of the patient, and have regard to her freedom from any tendency to ventral hernia. For this reason the smaller the wound the better. The patient should not be allowed to stand until provided with a light abdominal support, which should be worn for a year after the operation. For several months no heavy or fatiguing work should be undertaken. In all cases which survive, the operator will find it an advantage to keep the patient under observation, and to make her report her condition at intervals for a year or more, or until the ultimate results of the operation are established. This is particularly applicable to cases in which, for any reason, both ovaries have been removed. *James B. Hunter.*

OVARY, THE. (Ger., Eierstock; Fr., ovaire; Lat., ovarium; testes muliebres, Galen.) The ovary is classed among the internal organs of generation of the female. It is the analogue of the testis in the male, and furnishes the ovum, the female element in generation. The ovaries are two flattened, oval bodies, one on each side of the fundus uteri, and attached transversely to the posterior fold of the broad ligament. In the adult they are situated below the brim of the pelvis, but in the fœtus are found in the lumbar region. During pregnancy they, with the uterus, rise out of the pelvis. After delivery they are found as high as the iliac fossæ.

The ovary measures from one to one and a half inch in its long diameter, from three-fourths to one inch in breadth, and from one-third to one-half of an inch in thickness. These dimensions vary, not only in different individuals but also at different periods of life. During the period of menstruation the organ has been found enlarged in size.

The surface of the ovary during childhood is smooth. At puberty and thereafter it is found to be rough on its exterior, and marked with small cicatrices due to the rupture and closure of the Graafian follicles.

The ovary has a free convex border, and also a flattened border which is attached to the broad ligament. The hilus, an opening through which the blood-vessels, nerves, and lymphatics gain access to the interior of the organ, is on the attached border.

Structure.—The ovary is described as consisting of the epithelium or external covering, the connective tissue stroma, the parenchyma or glandular portion (the Graafian follicles), and, lastly, the blood-vessels, nerves, and lymphatics.

The epithelium—cylindrical in shape—covers the surface of the ovary and gives the organ a peculiar, dull, grayish-pearly lustre, differing markedly from the shining appearance of the neighboring pelvic organs which are covered by peritoneum. This epithelium has been named the "germ epithelium" by Waldeyer, because in the developing ovary it plays a genetic rôle in the formation of the ovule and Graafian follicle. In the fœtal ovary, in addition to the ordinary cylindrical epithelium, we have a number of large spheroidal, granular cells embedded at intervals in the layer of the "germ epithelium." These cells, the "egg-cells" (Pflüger), are destined, in the course of development to become the ovules of the Graafian follicle. They are also known as primordial ova. If the attached border of the ovary is examined, the germ epithelium is seen marked off from the peritoneum of the broad ligament by a fine white line.

The Stroma.—A longitudinal section of the ovary shows it to be marked out into two regions. One contains almost exclusively the parenchymatous element, the follicles, and a little connective tissue. This is called the cortex or zona parenchymatosa (Waldeyer). Deeper in

the substance of the organ the follicles are not found, but the connective tissue and blood-vessels are much more abundant. This part is called the medulla. The connective-tissue stroma forms in the cortex the framework for the Graafian follicles. In the medullary portion it forms a compact mass, and at the hilus merges into the tissue of the ligamenta lata and ovarii. It becomes loose in texture at the hilus in the vicinity of the larger blood-vessels. In the cortical portion, immediately under the epithelium, the connective tissue arranges itself into a thin, compact, and distinctly marked zone. Formerly this was described as forming a species of capsule for the organ, and was named the tunica albuginea. There is no true capsule or tunic, however, to the ovary, nor can this layer of connective-tissue stroma be stripped off the organ as a distinct structure. The connective tissue resembles in minute structure the interstitial tissue of other organs, and contains flat, cellular elements with elastic fibres. From the region of the hilus and medulla, trabeculæ pass into the cortical region between the follicles. In the albuginea its stratified structure is apparent. In young animals no so-called "albuginea" exists, and the follicles are found immediately beneath the germ epithelium. The elastic elements of the connective tissue are more abundant in the medullary portion of the ovary. In addition to the above there are a number of star- and spindle-shaped cells scattered in different parts of the stroma. The spindle-shaped cells are quite numerous in the vicinity of the sheaths of the blood-vessels, and some anatomists (Waldeyer) look on them as smooth muscle-cells; by others (Toldt) they are classified as connective-tissue elements.

The Graafian follicles (ovisacci, ovula Graafiana) form the parenchyma or glandular elements of the ovary. They

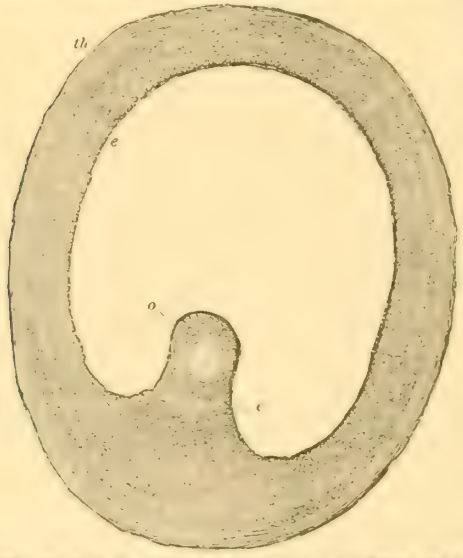


FIG. 2720.—Section of a Graafian Follicle from the Ovary of a Guinea-pig. *th*, Theca folliculi (with its two tunics); *e*, membrana granulosa; *c*, cumulus ovigerus; *o*, ovum, with its bursting membrane and nucleus. Hartnack, objective V., eye-piece 2. (Toldt.)

are found singly or in groups in the cortical zone (zona parenchymatosa, Waldeyer) of the ovary, and are of varying size. The smaller follicles are spheroidal. The larger and more developed structures may have an oval or an irregularly spherical shape. In the fœtal ovary of some animals (cat, rabbit) the smaller follicles are aggregated at the periphery of the cortical zone immediately underneath the "germ epithelium." Schrön thought they were a variety of cell, "egg-cell," and called this region the cortical zone of egg-cells. In the adult the larger-sized follicles are found embedded deeper in the cortical tissue and farther from the surface of the ovary than the smaller structures. The follicles do not encroach upon that region of the connective-tissue stroma known as the "albuginea."

The primordial follicle (developing follicle) in the human fœtus at the seventh month has a diameter of 30 to 100 μ. In the adult ovary the follicles vary in size from 30 or 40 μ to 10,000 or 12,000 μ, the latter being the mature follicle (Waldeyer).

The fully developed Graafian follicle in mammalia consists of a connective tissue envelope, the theca folliculi. This connective-tissue structure is really a part of the stroma of the ovary. It has an arrangement into an external layer, the tunica fibrosa (Henle), and an internal layer, the tunica propria folliculi. The tunica fibrosa is a thin zone of fibrillar connective tissue. The tunica propria is more vascular, and consists of spindle- and stellate-shaped young connective-tissue cells, capillary blood-vessels, and also round, wandering cells. These two layers merge into each other. In the smaller follicles the above structure of the theca folliculi is not seen, and the collection of cells and ovule making up the young follicle are found to lie simply in a space in the ovarian stroma.

Internal to the theca folliculi there is a layer of epithelial cells called the membrana granulosa folliculi. These cells are several rows deep, and those adjoining the theca are columnar in shape and have spheroidal nuclei. At one point in the membrana granulosa the cells are heaped into a spheroidal mass called the discus proligerus or cumulus ovigerus or germ hill. In the midst of the cells composing the discus there is a transparent vesicle, the ovum or egg. Some authors (Kölliker, Balfour, Foulis) describe a membrana propria folliculi situated between the theca folliculi and the membrana granulosa. Equally competent observers (Henle, Waldeyer) have failed to find this structure in the small or large follicles of the mammalia. In the centre of the follicle we have a space of some size not encroached upon by the membrana granulosa. This, the cavity of the follicle, is filled by a clear fluid, the liquor folliculi. The cells of the membrana granulosa are devoid of membrane, have elliptical nuclei, and are connected by cement-substance. Some contain fat-granules, others refracting drops like vacuoles. Some cells have an irregular shape. The liquor folliculi is supposed to be formed by the solution and liquefaction of the cells of the membrana granulosa (Waldeyer, Foulis). The smaller follicles found in the ovary of the new-born child are spheroidal structures, composed at the periphery of a single layer of cuboidal cells, while within this layer, and filling up the cavity of the follicle, is found a clear vesicle with granular-cell body, nucleus, and nucleolus. This is the ovum. Sometimes two ova are found in a single follicle. In addition, we find in the stroma of the young ovary isolated collections of coarsely granular cells, which are sometimes situated between the follicles. These cells are those of the original ovarian loops (Pflüger), to be hereafter described, which have not been converted into Graafian follicles. These collections of cells have been named abortive follicles. During the subsequent growth of the follicle the layer of cuboidal cells (membrana granulosa) increases in size and amount. The ovum takes a position toward the periphery of the follicle. It may in some follicles, when fully developed, be found in the centre of the same.

The Ovum.—The ovum, or ovule, or egg, is, as above stated, found embedded in the mass of cells of the membrana granulosa of the Graafian follicle, called the discus proligerus. A full description of it will be found farther on, under the heading Ovum.

The Development of the Ovaries and Graafian Follicles.—In the embryo of the fowl Waldeyer has found that on the fourth day the Wolffian body becomes invested with columnar epithelium. This epithelial layer undergoes considerable thickening, both on the sides and in the median line of the Wolffian body. The thickening in the median line is in both sexes the first indication of the developing germinal organs. A small connective-tissue outgrowth, vascular and rich in cells, occurs beneath the site of the epithelial layer. The thickened epithelium is the germ epithelium of the future ovary. Among these epithelial cells some are prominent because of their spheroidal shape and large nuclei—these are the

so-called "egg-cells" (Pflüger) or primordial ova—and will form the ovule of the Graafian follicle. The above-mentioned connective-tissue outgrowth is the forming stroma of the ovary.

In the *human* subject the first *macroscopic* indication of the developing ovary is seen in the tenth week of fœtal life. It forms a flattened, elongated prominence on the external surface of the Wolffian body (Meyer).

The further development of the ovary and of the Graafian follicles consists in an ingrowth of the germ epithelium covering the surface of the ovary, and in a shooting forward of the vascular connective tissue forming the stroma of the organ. In this way we have an appearance produced, on longitudinal section of the fœtal organ, of loop-like prolongations of the epithelium on the surface of the organ into the connective-tissue stroma of the cortical zone (Pflüger's loops, ovarian loops or tubes).

The connective tissue so disposes itself subsequently as to encapsulate these epithelial masses growing down from the surface. In a later stage we find these loops subdivided into smaller collections of cells through the penetration of delicate connective-tissue processes into their midst. We finally have the appearance of small spherical balls of epithelial cells surrounded by a little connective tissue. Within the epithelial masses are found the above-mentioned large, spheroidal, nucleated cells (egg-cells), which have been carried with the germ epithelium in the course of ingrowth from the surface of the ovary. These cells are the primordial ova. In the original ovarian loops we often find many primordial ova or eggs, but on the final subdivision in the course of development there remains only one ovum to each group of cells (follicle).* At birth it is believed that all the follicles have been formed in the ovary for the lifetime of the individual. They only undergo an advanced development after birth. It has been, however, observed in the recently burst Graafian follicle (after puberty) that the germ epithelium dips down toward the opening in the theca folliculi (Waldeyer). After a time a structure is found at this point resembling a rudimentary ovarian loop. It is very probable that even after puberty Graafian follicles are being formed from the germ epithelium. From what has been said above, the ovary may be looked on as a *gland* whose most essential elements, the ova, are not produced by it; but are already present, from the very beginning of its development, in the shape of the "egg-cells"—"primordial eggs."

The Corpus Luteum, or Yellow Body.—The number of Graafian follicles at birth is estimated at from 30,000 (Henle) to 400,000 (Sappey). According to some anatomists no Graafian follicles are formed after birth. Before and after puberty the smaller follicles, while changing into the more mature structures, gradually approach the surface of the ovary. The stroma recedes from in front of the advancing follicle. When the follicle reaches the surface of the organ the theca folliculi bursts at its thinnest part. The ovum is thus discharged from the cavity of the follicle. This process (ovulation) is constantly recurring, at regular intervals, in the human ovary. After discharge of the ovum the theca folliculi and follicular epithelium which remain behind undergo certain changes which give rise to an appearance called the corpus luteum. At puberty the surface of the ovary becomes marked with small prominent vesicles which, on examination, are found to be ripened Graafian follicles. At the most prominent and exposed part of each follicle the blood- and lymph-vessels of the theca folliculi have receded. There is seen, on minute examination, at this point an oblong spot (cicatrix, macula folliculi, stigma). It is here that the follicle bursts and discharges the ovum. In the interior of the follicle an extreme tension is caused by a proliferation of the cells of the membrana granulosa and those of the internal surface of the tunica propria folliculi; newly formed blood-vessels are also to be seen between the membrana granulosa and tunica propria. This, with the congestion attendant on the process of menstruation, no doubt determines the bursting of the follicle. There is still an uncertainty as to whether the proliferation of cells above mentioned begins with the membrana granulosa (Bischoff, Pflüger, Schrön, Zwicky), or the tunica propria (Baer, Spiegelberg, Kölliker, His, Benckiser), or both (Waldeyer). It is, however, certain that before rupture the membrana granulosa has increased in thickness through the addition of cellular elements, and the above-mentioned newly formed vessels are found. When the follicle bursts the ovum is discharged, with the cells of the discus proligerus adherent to it. Most of the membrana granulosa remains behind. An effusion of blood may take place into the cavity of the follicle immediately after bursting (Dalton, Leopold, Benckiser), or this may be absent, and instead, the cavity of the follicle is seen filled by a gelatinous fluid with granular detritus. Both these conditions have been seen in the same ovary. The corpus luteum, which has really begun to develop before rupture of the follicle, reaches its full maturity some weeks after. When fully developed it has the following structure: It has a size of from twelve to nineteen millimetres (Dalton), and consists of a central portion which, at first red, changes to a grayish-red color, and of a peripheral portion, the remains of the tunica propria and membrana granulosa. This peripheral part is thrown into folds caused by the growth of loops of blood-vessels from the inner surface of the tunica propria into the membrana granulosa (Benckiser). Later on, this convoluted wall assumes an intensely yellow color, from which the whole structure derives its name. The unchanged tunica fibrosa of the original follicle surrounds the whole. Dalton and Leopold describe the macroscopic appearance of the central portion as that of a condensed blood-coagulum, of a grayish-red color. Waldeyer describes it as being, in the recent follicle, of a minute microscopic structure similar to mucous tissue, and highly vascular. In a retrograde stage of the corpus luteum it contains hæmatoidin crystals. The peripheral portion consists of polyhedral cells varying in size, with large, transparent nuclei. Masses of fat-droplets are found round the nuclei, and in the human subject granules are found (lutein, Benckiser). This cellular mass is traversed by an abundant net-work of blood-vessels, in whose meshes the cells are found. The larger blood-vessels form papilla-like processes toward the central part of the corpus luteum, giving the body the above-described convoluted appearance. In addition we have migrated cells from the blood-vessels. Benckiser has observed in the human subject a partial division of the nuclei within the cells of the tunica propria (karyokinesis) during the formation of the corpus luteum. When the corpus luteum reaches the development above described, it enters into a series of retrograde changes due to an atrophy of the blood-vessels (His). There finally remains in the ovary a white trace (corpus albicans), as the final remnant of the corpus luteum. This cicatrix, microscopic in size, finally disappears also, and nothing can be recognized of the former follicle in the stroma of the ovary.

In the human subject, if the ovum does not become impregnated, the corpus luteum is called, for convenience, the *false corpus luteum*, or corpus luteum spurium. It is found in ovaries independent of pregnancy. This corpus luteum reaches its highest development at the end of three weeks, when it begins to decline. At the end of two months we have nothing left but an insignificant cicatrix. If impregnation occur, however, the corpus luteum develops slowly, and attains its largest size at the end of two months. It now remains stationary until the end of the sixth month, when it becomes smaller, loses its bright-yellow color, and at the end of pregnancy measures half an inch in diameter (Dalton). This has been called the *true corpus luteum, corpus luteum verum gravidarum.* While the corpus luteum occurring independently of pregnancy passes through its phases of growth and retrograde metamorphosis in two months, that of pregnancy takes nine to ten months for the same series of changes, and is at all times larger and more consistent in organization. Its yellow color, however, is striking, but temporary, and disappears after the sixth month

* The earliest period at which primordial follicles have been seen in the human subject is the fifth month of embryonic life (Sinety).

(Dalton). It is very probable that, even before puberty and the establishment of ovulation, a retrograde change is also constantly taking place in some Graafian follicles *without* bursting or the discharge of their contents. These changes, minutely described by Slaviansky, are very similar to those which occur during ovulation. It has been seen also in pathological conditions (amenorrhœa, fevers).

Blood-vessels.—Numerous branches from the spermatic and uterine arteries enter the hilus, divide, and subdivide in the medullary portion. Toward the periphery of the medullary portion the blood-vessels form a rich net-work; hence this portion of the ovary has been called the zona vasculosa. From this region small branches ramify between the follicles in the connective-tissue stroma of the cortex. These vessels are notable for their twisted, "corkscrew-like" course, and the richness of smooth muscle-cells in their walls. The *veins*, which are thin-walled, are numerous, and in the hilus form a rich plexus.

Lymphatics.—The ovary is rich in lymphatics, both in the stroma and in the theca folliculi (His, Slaviansky). They form larger trunks in the hilus, and leave the ovary at this situation with the veins. In the broad ligament they become valvular in structure. They empty into the plexuses formed by the lymphatics of the uterus and those about the vasa iliaca. Exner and Buckel deny the presence of lymphatics in the ovary, and only admit the presence of lymph-spaces in the stroma.

Nerves.—The nerves of the ovary remain still to be investigated; they are derived from the spermatic and ovarian plexuses. They form, in the theca, plexuses of non-medullated fibres. From this part small nerve-fibrils penetrate the granulosa and are thought to have their endings in the cells of the granulosa (Ellischer).

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Henry Koplik.

OVUM. The term *ovum* is employed in various senses. It is applied (1) to the cell distinguished as the ovarian cell or *immature ovum*, out of which the female product or mature ovum is developed; (2) to the *mature ovum*, or true female spore; (3) to the mature ovum *plus* the fecundating spermatozoon united with it—that is, to the *impregnated ovum*; (4) to various stages of development of the embryo. In this article we consider only the ovum in the strict sense, namely, as the female sexual product. For the further history see Impregnation (vol. iv., p. 5), Segmentation of the Ovum, and Fœtus, Development of (vol. iii., p. 171).

The ovum arises as a cell, which matures by a series of changes, of which the last and most striking is the expulsion of the so-called polar globules; there are many important changes which occur earlier. The genesis of the mature ovum may be conveniently divided into three arbitrary stages: (1) Differentiation of the ovic cell; (2) growth of the cell and accumulation of nutritive material in it; (3) maturation proper.

1. The Origin of the Primitive Ova (Urei or Ovic Cells).—It seems to me, in the light of the recent investigations of the origin of the ova in vertebrates, safe to assert that they arise from cells of the mesothelium (peritoneal epithelium) covering the genital ridge of the embryo, the ridge giving rise to the adult ovary. On account of its function the epithelium of the genital ridge has been called the germinal epithelium (Keimepithel). In mammals, which alone will be here considered, according to the best authorities the *ovaria* are developed as follows: Certain cells of the germinal epithelium (Fig. 2721, *c*, *c*) become larger than the others; these cells are soon carried into the interior of the ovary by being included in cord-like ingrowths of the epithelium (Fig.

Fig. 2721.—Part of a Sagittal Section of an Ovary of a New-born Child. (From Waldeyer.) *a*, Ovarian epithelium; *b*, commencement of one of Pflüger's cords; *c*, *c*, primitive ova in the epithelium; *d*, *d*, a solid Pflüger's cord with developing ova; *e*, *e*, cords developing into follicles; *f*, young follicle; *g*, *g*, blood-vessels.

2721, *b* and *d*, *d*). These cords are the "*Pflügerschen Schläuche*" of German writers. The primitive ova exist in multiple in the cords *d*, *d*, but each of them early becomes surrounded by a separate envelope of epithelial cells. A little later each ovum separates from its neighbors and appears as a round cell, with a clear nucleus and distinct nucleolus, *f*, closely invested by a layer of cells smaller than itself. The young egg-cell, together with its epithelial envelope, constitutes the so-called primordial follicle (Fig. 2721, *f*).

2. Growth of the Ovum and Development of the Yolk.—The modifications which occur in growing egg-cells are as follows: 1. Change of size: the cell enlarges, it being a rule—no exception to which is, I believe, known—that the mature egg-cell is much larger than any of the other cells in the body of the parent. 2. Change of shape; the cell usually becomes nearly or quite spherical; the shape of the egg does not necessarily remain spherical, but may be altered by external pressure, as in the uterus of Arion (vol. iv., p. 7, Fig. 1815), or as when several are laid in one capsule (Lumbricus, Nephelis, Planaria, etc.), or when compressed by an unyielding shell. A very striking instance of the last mentioned kind has been described by Repiachoff (*Zeitschr. f. wiss. Zool.*, xxx., Suppl.), who figures the egg of a European bryozoön found on eel grass as fusiform (Fig. 2722). 3. The nucleus becomes larger, spherical, and assumes an eccentric position within the cell; the chromatine usually gathers into one nucleolus, as in mammalia; the nucleolus is large, distinct, highly refrangent, easily stained, and placed eccentrically within the nucleus. The achromatic substance or protoplasm of the nucleus develops into a coarse net-work, which radiates irregularly from the nucleolus as a centre. 4. The cellular net-work becomes very distinct; its interspaces become filled with ovoid, round, or crystalline

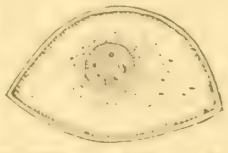

Fig. 2722.—Egg of Tendra Zostericola. (After Repiachoff.)

solid inclosures, which are usually if not always mainly of an albuminoid character. The inclosures form the part which is called the deutoplasm by Edouard van Beneden and others. The deutoplasm is the same as the yolk substance of older writers, and is a store of nutritive material from which the protoplasm draws subsequently to support its growth. The term yolk has no very exact meaning, for it is used to designate, sometimes the deutoplasm alone, sometimes the whole ovum proper, as when the segmentation of the yolk is spoken of. 5. In all vertebrates an ovarian envelope, the *zona radiata*, is formed.

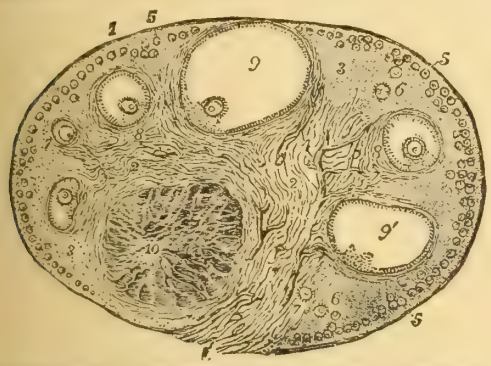

Fig. 2723.—Section of the Ovary of a Cat. × 6 diam. (After Quain, from Schrön.) 1. Outer covering and free border of the ovary; 1′, attached border; 2, the central ovarian stroma, presenting a fibrous and vascular structure; 3, peripheral stroma; 4, blood-vessels; 5, Graafian follicles, in their earliest stages, lying near the surface: 6, 7, 8, more advanced follicles, which are embedded more deeply in the stroma; 9, an almost mature follicle, containing the ovum in its deepest part; 9′, a follicle from which the ovum has accidentally escaped; 10, corpus luteum.

6. It is probable that a vitelline or true cell-membrane is always formed inside the zona by the egg-cell before it reaches maturity.

Such are in general terms the processes in the development of animal ova. We pass to a review of the processes as they are modified in the vertebrates, and especially in the mammalia.

It will be convenient to describe first the change of the primordial follicle into the Graafian follicle. The former has at first only a wall of flattened cells as the epithelial envelope of the ovum. In sections the cells look spindle-shaped in the human subject, and not very unlike the cells of the ovarian stroma, so that they were thought by Foulis to be derived from the stroma, but it must now be considered as settled that the follicular walls, like the ova themselves, are derived from the germinal epithelium. "These smallest follicles are very numerous, especially in the young subject; indeed, it has been computed that in the ovaries of a female child at birth there cannot be fewer than seventy thousand of them. If this is the case a large proportion must degenerate and disappear without coming to maturity. In follicles which are a little larger, fluid is seen to be accumulated between the two layers of cells, and thus to distend the follicle. This collection of fluid is absent at one part, generally that which is directed away from the surface of the ovary, so that here the cells which surround the ovum are in continuity with those which line the follicle, and the ovum is thus in a manner attached at this place to the wall of the follicle (Fig. 2723). In the largest follicles the chief difference in the contents of the follicle consists in the far greater accumulation of the liquor folliculi, and in the multiplication of the epithelium-cells —both those which line the follicle (*membrana granulosa*) and those which invest the ovum (*discus proligerus*) —so that each of these parts consists, in large follicles, of several layers of cells, mostly rounded or irregular, but columnar next the wall of the follicle and the exterior of the ovum, respectively.

"The larger follicles have a very distinct wall, which is continuous with, and derived from, the stroma of the ovary, and is separable into two parts, an inner, containing the ramifications of the capillary blood-vessels, which are abundantly distributed to the larger follicles, but nowhere penetrate among the epithelium cells; and an outer part, more fibrous, in which the larger branches of the blood-vessels of the follicles run. In both layers of the follicular wall the cells are similar to those of the general stroma, interstitial cells occurring abundantly; but it is uncertain whether there are any cells present of the nature of muscular fibres. The smaller blood-vessels running round the follicle from below, and minutely subdivided on its inner surface, converge toward a point near the middle of the most projecting part called the stigma. This marks the spot where the rupture of the vesicle ultimately occurs, when fully matured. Each Graafian follicle usually contains only a single ovum; but occasionally, though seldom, two ova, and very rarely three, have been observed in the same follicle" (Allen Thompson).

Shortly after the separation of the granulosa from the discus there appears a narrow light space between the latter and the ovum; the space is due to the commencing development of the ovarian envelope of the ovum, the *zona radiata*. Processes from the cells of the discus proligerus run through the zona, and are probably the channels by which nutriment is brought to the egg-cell. The zona itself gradually thickens as the ovum enlarges.

About the same time that the zona appears fine granules also appear in the ovum; they are the first particles of yolk substance or vitelline matter. In the mammalian ovum the yolk never attains a great development; but in most vertebrates the granules gradually enlarge, and in some cases they are quite big. When they are thus developed it is easy to see that they are of various sorts. Thus in the hen's ovum there are two principal kinds of yolk-grains, the yellow and the white. The yellow grains are spheres of from 25 μ to 100 μ in diameter, filled with numerous minute, highly refractile granules; these spheres are very delicate and easily destroyed by crushing. When boiled or otherwise hardened *in situ*, they assume a polyhedral form from mutual pressure. The white grains are vesicles, for

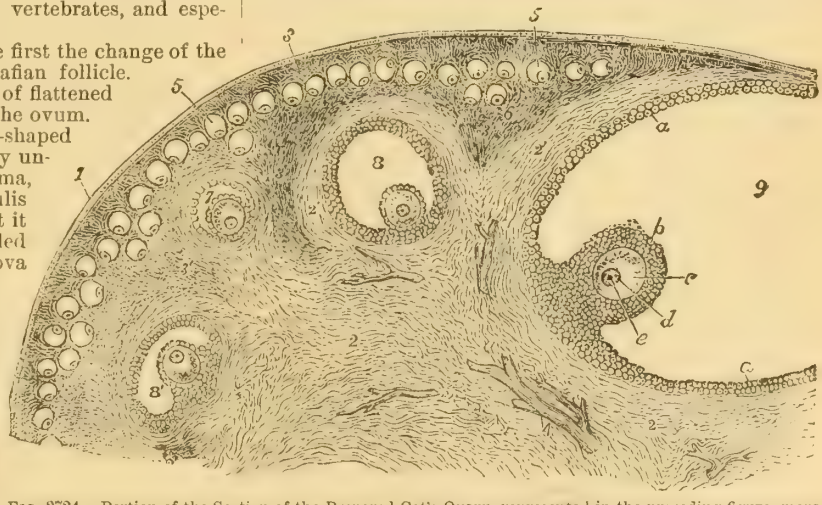

Fig. 2724.—Portion of the Section of the Prepared Cat's Ovary, represented in the preceding figure, more highly magnified. (From Schrön, in Quain's Anatomy.) 1, Epithelium and outer covering of the ovary; 2, 2′, fibrous stroma; 3, 3′, less fibrous, more superficial stroma; 4, blood-vessels; 5, small Graafian follicles near the surface; 6, one or two more deeply placed; 7, one farther developed, inclosed by a prolongation of the fibrous stroma; 8, a follicle farther advanced; 8′, another, which is irregularly compressed; 9, part of the largest follicle; *a*, tunica granulosa; *b*, discus proligerus; *c*, ovum; *d*, germinal vesicle; *e*, germinal spot.

the most part smaller (4 μ to 75 μ) than the spheres of the yellow yolk, with a highly refractive body, often as small as 1 μ in the interior of each. There are also larger spheres, each of which contains a number of spherules similar to the smaller vesicles. The yolk-plates of plagiostomes, which consist principally of lecithine and nuclein, are not present in the younger ova, but are present in great numbers in the full-grown ones; they are oval, barrel-shaped, or rectangular bodies, with rounded corners and edges; the surface, especially in the larger plates, shows a fine transverse striation, corresponding to the laminate structure of the grain. As no thorough comparative investigation of the yolk-granules has been made, it is not worth while to enter into further details.

Fig. 2725.—Egg-cell of Tegenaria domestica. *n*, Nucleus; *k*, laminate yolk-nucleus. (After Balbiani.)

Besides the yolk-grains there may also be present one or several large masses of nutritive material, such as the "oil-globules" of many teleosts, or the so-called yolk-nucleus. The "oil-globules" are produced by the liquefaction of the yolk, and are not oily. The yolk-nucleus has been described by Balbiani in the arachnida. The eggs of some spiders contain, besides the nucleus, a second body (Fig. 2725, *k*), of about the same size as the nucleus, solid, resistant, and exhibiting indications of a series of concentric laminæ; this is the so-called yolk-nucleus, and is probably only a specialized form of deutoplasm, and might be compared, for instance, to the four large oil-globules described by Spengel in the eggs of Bonellia viridis. A yolk-nucleus has since been recorded in the ova of various vertebrates; thus Schütz ("Ueber den Dotterkern," Diss. Inaug., Bonn, 1882) found in the ovarian ova of the pike, in September and October, a round or oval body, not sharply delimited, clear and more homogeneous than the protoplasm, and which increased in size with the growth of the egg. A yolk-nucleus, consisting of an accumulation of larger and smaller granules, has also been observed in the frog and newt, but is apparently wanting in Bufo and Bombinator (Götte).

The amount of yolk varies in different animals very greatly, and determines apparently the size of the ovum. It has been observed that the process of segmentation varies according to the amount of yolk, and this has led to the arbitrary division of ova into mesoblastic and holoblastic (see Segmentation of the Ovum). The yolk usually, perhaps always, leaves a peripheral layer of protoplasm free. In all vertebrate and in some invertebrate ova this layer of protoplasm is thickened, often considerably, around one pole of the ovum, which is then distinguished as the animal pole, the opposite pole being called the vegetative. These are old terms which have come down to us from the time when the ectoderm, which is produced during segmentation, principally from the substance of the animal pole, was called the animal layer, and the entoderm the vegetative layer. It is at the animal pole that the extrusion of the polar globules under normal conditions invariably takes place.

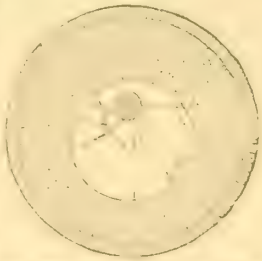

Fig. 2726.—Fully grown Ovum of the Sea-urchin. (After C. Hertwig.)

A typical, full-grown egg-cell of the holoblastic type, *i.e.*, with little yolk, before the expulsion of the polar globules, is shown in Fig. 2726, which represents the ovum of *Toxopneustes lividus*, the common sea-urchin of Europe. The nucleus is proportionately larger than in the eggs of many other animals; its contents are fluid except the net-work and the nucleolus, which latter has frequently one or more vacuoles. In some forms, as stated above, the chromatine forms several nucleoli; this is the case in many teleosts and in the batrachia. The nucleus and the nucleolus of ova were known long before the establishment of the cell-doctrine, and received special names which are still in use. The nucleus was termed the *vesicula germinativa*, or, after its discoverer, Purkinje's vesicle; the nucleolus, the *macula germinativa*; the equivalent German terms are *Keimbläschen* and *Keimfleck*, respectively.

The ovum of man and other placental mammals is extremely small, measuring about 0.2 millimetre in diameter. It was first discovered by C. E. von Baer in 1827. Previously the Graafian follicles had been mistaken for the true ova. Within the zona pellucida and vitelline membrane (*cf.* § 4) lies the spherical yolk, Fig. 2727, which consists of reticulate protoplasm, with embedded small yolk granules. At least three forms of granules are said to occur: 1st, very small ones; 2d, larger ones inclosing lesser granules, as do the white-yolk grains of birds; 3d, small, spherical, glistening granules, which are stained by osmic acid. The yolk is most developed in carnivora (Thompson). Schütz and Rein have described a yolk-nucleus in the rabbit's ovum. The nucleus

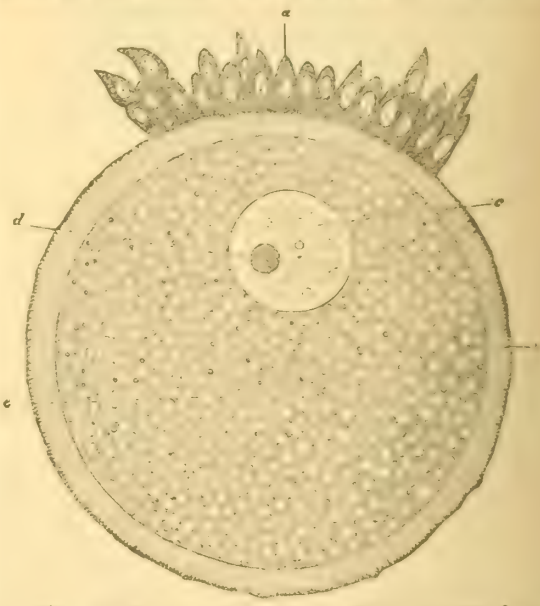

Fig. 2727.—Rabbit's Ovum, from a Graafian Follicle measuring 2 mm. *a*, Discus proligerus; *b*, zona radiata; *c*, nucleus; *d*, nucleolus; *e*, yolk. (From Waldeyer.)

was first discovered in mammals by Coste. It is a round vesicle, Fig. 2727, measuring 25 to 35 μ in diameter (Schulin), occupies an excentric position, has a distinct, tough membrane, which is covered with small holes; it contains a homogeneous or granular enchylema, a coarse protoplasm net-work, and a distinct, large, excentric nucleolus; it may also contain a few distinct grains (Fig. 2727) and a vacuole.

3. Maturation.—The term maturation is restricted by usage to the phenomena accompanying the expulsion of the polar globules, which occurs after the egg-cell has attained its full size, and just before or just after the separation of the ovum from the ovary.

When an ovum attains maturity the nucleus moves close to its surface, where it disappears. This disappearance of the germinative vesicle was observed long ago, but remained inexplicable until the observations of recent years demonstrated that in many, if not in all ova, the disappearance is not a real one, but only a metamorphosis, connected with the production of the polar globules. The polar globules have now been described in almost every class in the animal kingdom, and it is probable that development of polar globules or of homologous structures is indispensable for the ma-

turation of the ovum, that is to say, for the conversion of the egg-cell into the female spore. Taking the observations thus far published as a basis, the following may be given as a generalized statement of the essential phases of the genesis of the polar globules. When the nucleus disappears it is replaced by a spindle-shaped body known as the *Kernspindel*, or, Anglicè, *nuclear spindle*, which is the nucleus changed in shape and structure. It consists (Fig. 2728, *sp*) of a small number of fine threads, which are modifications of the achromatine or protoplasmic net-work of the nucleus; they converge toward each end. The chromatine breaks up into separate fragments, which appear in one plane in the centre of the spindle (Fig. 2728), and produce the appearance of a transverse band or disk (Strassberger's *Kernplatte*). Each chromatine fragment is especially associated with one of the spindle-threads described above. The spindle lies perpendicular to the surface of the egg. Each pointed end of the spindle occupies the centre of a clear space, from around which radiate fine threads in the yolk, whence results a figure like a conventional sun. The whole spindle, with the two suns, has been named the *amphiaster*. Sometimes, as in limax (Mark), the astral rays are not straight, but curving like a turbine.

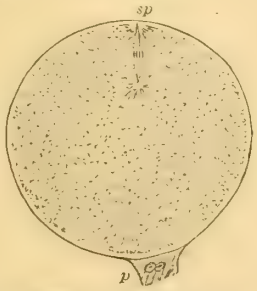

Fig. 2728.—Ovarian Egg of Hæmops. *sp*, Nuclear spindle; *p*, peduncle attaching the egg to the ovary. (After O. Hertwig.)

The next changes may be followed with the help of Fig. 2729. The spindle is here partly extruded from the egg; one end projects outward and is inclosed by a distinct mass of protoplasm, *p. g.*, which is constricted around the base. The fragments of chromatine, constituting the *Kernplatte*, have all divided in two, and one-half of each fragment has moved toward one end, the other half toward the other end of the spindle. Each set of half fragments move together, hence there seem to be two plates in the spindle. The translation of the groups of chromatine grains continues until they reach each one end of the spindle; the threads break through in the middle. Thus the original nucleus has been divided; each of its parts resumes more or less the ordinary nuclear structure; there are now two nuclei, one in the ovum, the other in a little appendage to the ovum. This appendage is the first polar globule. The nucleus in the ovum after a short interval transforms itself into a second spindle, which develops a second polar globule in similar manner to the first. Frequently the first polar globule divides into two, so that there are three in all. This is the usual number. The connection of the globules with the yolk lasts some time, and in the case of leeches is not dissolved until segmentation begins. These globules take no part in the further history of the egg—they break off and may be distinguished for a while during the early stages of segmentation. They ultimately disappear—how, is not exactly known. The part of the spindle in the egg-cell returns toward the centre of the ovum and becomes a nucleus-like body, which is now termed the female pronucleus.

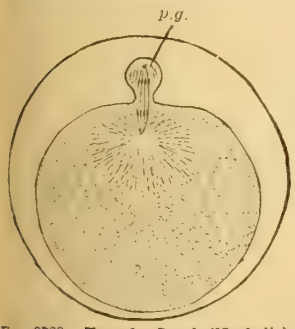

Fig. 2729.—Egg of a Leech (Nephelis), three-quarters of an hour after being laid. Formation of the first polar globule. (After Hertwig.)

The details of the formation of the polar globules are, as has been specially emphasized by Carnoy,* by no means constant. It does not seem desirable to enter here into details, especially as we possess at present no satisfactorily thorough account of the formation of the polar globules in mammalia. In mammals the development of the polar globules begins in the ovary—but in some other animals it commences latter.

The history of our knowledge of the maturation of the ovum deserves a few words. The fact that the nucleus disappears was first published in 1825 by Purkinje, and since then it has been repeatedly observed and by many investigators. The fact that the disappearance is only apparent was first made known in 1876 by Bütschli, and a little later by O. Hertwig. The polar globules were discovered by Fr. Müller and Lovén in 1848, and since then have been found in the great majority of ova, but not as yet in any of the vertebrate ova with much yolk, that is, not in the selachian, reptilian, or avian ovum. Since the discovery of the origin of the polar globules by the intervention of the nuclear spindle, many biologists have investigated the subject, which, therefore, has an extensive literature.

The significance of the polar globules has been much discussed. There are two principal hypotheses—1st, that of Minot; 2d, that of Whitman. Most of the interpretations hitherto offered are affiliated with one of these hypotheses. Minot's view assigns to the polar globules the function of taking from the egg-cell something which it is indispensable to remove in order to convert the cell into a sexual element; he considers that the cell is really hermaphrodite, and the polar globules *male;* their expulsion leaves the *female* element behind. Balfour has defended this view, and Édouard van Beneden has sought to appropriate it. Whitman's hypothesis regards the formation of the polar globules merely as a process of cell-division; a last effort of the egg-cell at self-multiplication. Bütschli compares this effort to the productivity of a semen-mother-cell (spermatocyst) and suggests that originally the one cell produced several ova, just as it still produces several spermatozoa. For a fuller discussion of these theories see Sex.

4. The Envelopes of the Ovum.—The eggs of different classes, and even species, of animals are, as is well known, extremely unlike in appearance. The dissimilarity refers chiefly to size, to the character of the yolk, and the nature and number of membranes or other envelopes by which the ovum or egg-cell proper is surrounded. Thus in the hen's egg the yolk alone represents the part corresponding to the egg-cell, while the white of the egg and the egg-shell are only secondary envelopes, the former serving to nourish, the latter to protect the yolk, which is the essential part, the true egg. The various envelopes which eggs ever have, may be classed under four categories: *First*, a very thin and delicate one, the proper membrane of the cell itself, and which ought always to be distinguished as the vitelline membrane; *second*, the ovarian envelope, which is secreted around the egg-cell by the tissues of the ovary; *third*, the envelopes secreted by the oviduct, which may form a coating of nutritive material, or a protective shell, or both, as in the hen's egg, of which the nutritive white is secreted by the upper part, the calcareous shell by the middle part of the oviduct; *fourth*, coverings secreted by accessory glands, such as the slime, in which the eggs of snails are embedded, or the touch capsules, in which leeches lay their eggs. By adhering to this classification it is possible to find one's way through the labyrinth of special descriptions. It is impossible to review here the manifold variations in the ovarian coverings of animals, and we shall attempt only to describe those of the higher forms.

All vertebrate ova probably have two envelopes; first, a very thin inner one, the vitelline membrane proper, and second, a thicker ovarian membrane, known as the *zona radiata* or *pellucida*. The vitelline membrane is described by Heape, in the mole, as a very thin but distinct membrane (Fig. 2730, *v.m.*), immediately against the yolk, separated by a narrow space from the zona; it is to be regarded as a product of the ovum itself. It appears a short time before the ovum matures, and is most distinct at the time of the formation of the polar globules; its fate

* See especially Flemming, Arch. Mikrosk. Anat., xxix., 449.

during segmentation has not been ascertained. The so-called vitelline membrane (Dotterhaut) of amphibia is really the homologue of the zona (Frommann). Considerable doubt in regard to the presence of this membrane in vertebrates, and especially in mammals, has been expressed by various writers, but its existence seems to me to have been sufficiently demonstrated. It was first described by Reichert, in 1841, and again by H. Meyer, in 1842. In recent years it has been redescribed by Éd. van Beneden, by Heape, and others. Balfour, in his "Embryology," pronounces in favor of its occurrence. The *zona radiata* (*pellucida* of C. E. v. Baer), Fig. 2730, *z*, is a membrane, usually of considerable thickness, which can be distinguished around the ovarian ovum quite early, being at first very thin, but gradually increasing in thickness until it attains in man a diameter of 0.018 to 0.020 mm., in the mature ovum. In the pig the diameter becomes 7 to 9 μ; in the sheep, 7 to 12 μ; in the cow, 7 to 8 μ (Schulin); in the mole, 8 to 11 μ, according to Heape. In the mature ovum it is a tough, clear, glistening membrane, very resistent to acids, and soluble in alkalies only with difficulty. It is pierced by numerous radiating pores, which produce the appearance to which the term *zona radiata* refers. These pores were first observed by Johannes Müller and Remak in fish eggs, and they have since been observed in the ova of many other vertebrates, including several species of mammalia. It is probable

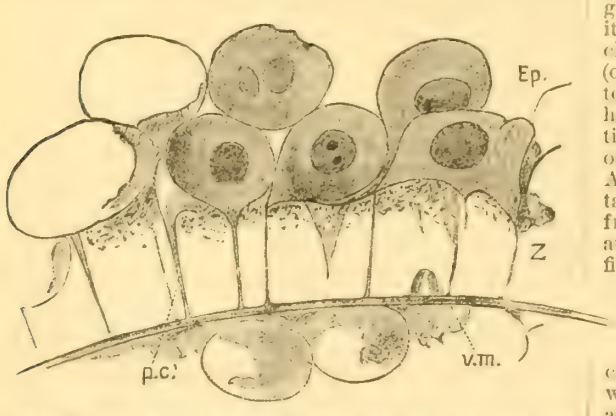

Fig. 2730.—Small Portion of a fully Grown Egg-cell of the Mole. (After Heape.) *Ep.*, Epithelium of the discus proligerus, constituting the so-called corona; *z*, zona radiata; *v.m.*, vitelline membrane; *p.c.*, pore canal of the zona.

that they always exist, despite the doubts expressed by Schulin, Luidgren, and v. Sehlen. While the ovum is still in the ovary, it is surrounded by the cells of the discus proligerus; these cells send processes through the pores of the zona (Fig. 2730). It is now commonly supposed that these processes are channels of nutrition for the ovum. The zona is somewhat granular in its outer portion, next the cells of the corona. Balfour has suggested, not very plausibly I think, that the granular portion does not belong to the zona, but represents the remains of a hypothetical primary vitelline membrane, within which the *zona* proper arose subsequently. It seems to me that the *zona radiata* is to be regarded as a modified intercellular substance, and that the processes going through its pores are to be homologized with the ordinary intercellular protoplasmic bridges of epithelial cells.

Heape thus describes the pores of the zona in the mole: "The radially striated appearance of the zona has long been shown to be due to a vast number of fine canals passing radially through it. The canals, I find, open on the inner side of the zona by a slightly dilated mouth, while on the outer side of the zona they communicate with the exterior by a considerably wider opening (Fig. 2739). Into the external openings of these canals I have been able to trace prolongations of those cells of the discus which are immediately in contact therewith (Fig. 2730), and there appears to me no room to doubt that the contents of these follicular cells are thus rendered available for the nutriment and growth of the ovum."

Luidgren, Sehlen, and Virchow affirm that follicular cells pass within the zona, but I am inclined to receive their statements with great caution. In certain fishes the zona has a special opening, the micropyle. Barry and others have asserted that a micropyle is present in mammalian ova, but their opinion is now generally believed to be erroneous.

The *corona radiata* is the name given to the envelope of cells of the discus proligerus, which adheres for a short time to the zona radiata when the ovum is discharged from the Graafian follicle. The corona may be represented only by a few patches of cells, or may be a complete envelope; in either case the cells are entirely lost soon after the ovum begins its descent through the Fallopian tube.

The disappearance of the zona has been specially studied by Tourneux et Hermann ("C. R. Soc. Biol.," Paris, 1887, p. 49), who found that it could be distinguished in rabbit's ova of ninety-five hours, but not in those of one hundred and sixteen hours. According to Hensen the zona in guinea-pigs is ruptured and the ovum escapes during the descent through the oviduct.

5. Ovulation, or the escape of the ovum from the ovary is effected by the rupture of the thinner or more projecting part of the Graafian follicle. The ovum, together with some of the discus proligerus adherent to it (the so-called corona), falls into the peritoneal cavity, close to the fimbriated opening of the Fallopian tube (oviduct), which it enters; its transit through the peritoneal cavity is very short. The discharge of the ova has been said to take place in the sheep and dog at the time of heat only, and it has been a prevalent view that ovulation coincided in man with the menstrual period. According to Leopold, the rupture of the follicle may take place in women at any period, although it is most frequent about the time of the menses. His conclusions are drawn from the very careful examination of twenty-five pairs of ovaries from women whose menstrual history was accurately known.

The rupture of the follicle takes place at the *cumulus* or *stigma*, the spot near the surface of the ovary where the follicular walls are thinner and less vascular than elsewhere. The physiological mechanism by which the rupture is effected has not yet been accurately ascertained. The emptied follicle fills up with blood, which forms a coagulum; the clot is replaced by a peculiar tissue characterized by very numerous large yellow cells, which impart the tint to the whole, justifying the designation corpus luteum (see Ovary).

6. Literature.—The fullest, clearest, and most trustworthy account of the ovum is, I think, unquestionably that presented by Frommann in his two admirable articles "Befruchtung" and "Ei," in the second edition of Eulenburg's "Real-Encyclopädie der gesammten Heilkunde." The literature is there cited *in extenso*. Good short résumés are to be found in Balfour's "Comparative Embryology," Hertwig's "Entwickelungsgeschichte des Menschen," and the ninth edition of "Quain's Anatomy." Exhaustive analyses of the special papers are given by Fol ("Recherches sur la Fécondation et le Commencement de l'Hénogénie," Genève, 1879) and Mark ("Bull. Mus. Comp. Zool.," v.). An invaluable collation of what is known concerning the egg and its envelopes has been published by H. Ludwig ("Semper's Arbeiten," Bd. ii.). Waldeyer still remains the best authority on the development of the ova (see his "Eierstock und Ei," and his chapter in Stricker's "Histology"). In the preparation of this article I have drawn freely from my own paper in the *American Naturalist* for February, 1880, and from Frommann and Quain.

[Note.—Since this article on the Ovum was put in type O. Schultze has published his observations on the maturation of the amphibian ovum in volume xlv. of the *Zeitschr. für wiss. Zoologie*, p. 177. This author has traced the disappearance of the yolk nucleus, so called; he denies the existence of *yolk-plates* except as artefacta, and finally he describes the formation of two polar globules, which,

on account of their minute size, had been overlooked until now. The nucleus of the ripening amphibian ovum is very large; when maturation begins it approaches the surface of the ovum, its membrane disappears, and the nucleus sap and most of the chromatine mingle with the yolk; a few fine chromatine granules remain in the centre of the nucleus; these fuse into irregular threads, which represent the skein (knäuel) stage in the formation of a nucleus spindle. A true though very minute spindle is formed, and divides to produce the first polar globule; a second globule also is then formed in a typical manner. These observations are important, as they reveal the occurrence of polar globules in a class of animals in which they had not been found by previous searchers. Schultze has given an important confirmation of the theory that in all ova the expulsion of polar globules is an important step, probably the essential step, in the maturation of the ovum. *Charles Sedgwick Minot.*

OWASSO SPRING. *Location and Post-Office*, Owasso, Shiawassee County, Mich.

Access.—By the Michigan Central (Saginaw Division), the Detroit, Grand Huron & Milwaukee, and the Toledo, Ann Arbor & North Michigan Railroads.

Analysis.—One pint contains:

	Grains.
Carbonate of magnesia	1.413
Carbonate of iron	1.443
Carbonate of lime	2.228
Chlorides of sodium and potassium	0.262
Silica and alumina	0.077
Total	5.423

Therapeutic Properties.—This is a chalybeate water of unusual strength. Some doubt exists as to the proportion of iron being as great as put down in the table of analysis.

Owasso is situated in the central part of Lower Michigan, seventy-eight miles northwest from Detroit. It has a population of twenty-five hundred. *G. B. F.*

OXALIC ACID. Oxalic acid, having no medicinal virtues, is not officinal in the U. S. Pharmacopœia, but its important toxicological relations require for it a brief notice. Oxalic acid, $H_2C_2O_4$, $2H_2O$, occurs in small, colorless, prismatic crystals, looking enough like crystals of magnesic sulphate (Epsom salt) to give rise to mistakes in careless dispensing. The crystals dissolve in alcohol, in eight parts of cold water, and in one part or less of boiling water, the solutions being of strong acid reaction and intensely sour to the taste.

Oxalic acid and the alkaline oxalates, which latter are all soluble in water, are powerfully poisonous, acting mainly by virtue of intense irritation, and even causticity, but also in part—so most authorities hold—by virtue of special affection of the muscular and nervous structures. Ringer considers that still an additional factor in oxalic-acid poisoning is the precipitation of the soluble lime salts in the blood by the action of the acid (*The Practitioner*, vol. xxxiv., p. 81). Oxalic acid itself is the form of the poison most commonly taken, and cases of poisoning by the agent are almost invariably through either accident or suicidal intent; for the intensely sour taste of even a small quantity of the acid practically prevents successful criminal administration. In cases of poisoning a considerable quantity—half an ounce or more—is commonly taken, and in fairly strong solution. The usual symptoms of irritant poisoning then set in, and at once—burning pain, sense of constriction in the gullet, and speedy vomiting of sour, brownish, or black matter, the dark coloration being due to the presence of altered blood. Cramps—a reflex of the gastric pain—are common, and collapse may speedily follow. Associated with these symptoms may also be sensory and motor disturbances, supposed to be due to a direct neurotic action of the poison, such as numbness and formication in the extremities, and spasms, tonic or clonic. Death follows at variable periods after ingestion, from three minutes, in an exceptional case, to fourteen days in a case proving secondarily fatal by starvation. The average period is about an hour. Urine voided during the poisoning will almost certainly develop, upon standing, a considerable precipitate of calcic oxalate in the usual octahedral crystals. The most marked post-mortem appearance in oxalic-acid poisoning is presented by the mucous membranes exposed to the direct action of the acid, which are commonly of a whitish color and softened. Actual corrosion is uncommon, and perforation of the stomach rare. Indeed, the poison may prove fatal and the gastric mucous membrane show only a slight congestion, an occurrence more common where the acid has been swallowed in comparatively high dilution. As regards fatal dose, the smallest reported is one drachm, and half an ounce (about 15.00 Gm.) will commonly kill unless treatment be promptly instituted. Yet, as usual in the history of poisons, even double the usual fatal dose has been taken and survived. In the matter of treatment, the only special points in the case of this particular poison are that the alkalies should be avoided for purposes of neutralization, since the oxalates of the alkali-metals are, as already said, soluble and poisonous; but that, on the other hand, calcic oxalate is peculiarly insoluble and therefore innocent, wherefore lime compounds—chalk, or whitewash scraped from a ceiling or wall—should be immediately and freely given. But, as is generally the case in irritant poisoning, the damage is commonly done before the antidote arrives, so that the latter is of little avail. Ringer advocates the administration of soluble calcic salts, such as the chloride, with the view of carrying the precipitation of calcic oxalate even to such of the acid as has gained entrance to the circulation. *Edward Curtis.*

OXALIC ACID, POISONING BY. The salt obtained by evaporation of the juice of *oxalis acetosella*, and now known as *binoxalate of potash*, *salt of sorrel*, or *salt of lemon*, was known at least as early as the middle of the seventeenth century, as Duclos makes mention of it in the "Memoirs of the Academy for 1668." A century later (in 1773) oxalic acid was obtained from this salt by Savary. Subsequently Scheele showed the oxalic acid obtained from sorrel to be identical with the *acid of sugar* obtained by Bergman, in 1776, by the action of nitric acid upon sugar.

The first case of poisoning by oxalic acid, of which we find record, occurred in England in 1814 ("Lond. Med. Repository," i., 382). In this case the acid was taken in mistake for Epsom salt, a mistake which has subsequently become the most frequent cause of oxalic-acid poisoning.

Attempts at homicide by oxalic acid are of rare occurrence, owing to the difficulty of disguising the taste. Yet Christison mentions one as having occurred in England in 1827, and others have been subsequently reported from the same country, the acid having been mixed with gin, coffee, sugar, tea, or buttermilk. So far as we can learn, this poison has not as yet been the successful instrument of murder.

Notwithstanding the very extensive use of oxalic acid and the oxalates in the arts of dyeing, calico-printing, etc., they are as yet innocent of industrial poisoning.

As many articles of vegetable diet—beet, spinach, rhubarb, sorrel, etc.—contain oxalates, their use in excessive quantity has been supposed by some to be attended with some danger of poisoning. As, however, the amount of hydropotassic oxalate present is only 0.75 per cent. (= 3 grains per ounce) in fresh (Mitscherlich) sorrel, and much less in the other vegetables, their use in any reasonable quantity may be considered as unattended with danger.

A more probable cause of poisoning is to be found in the adulteration of citric acid with oxalic acid, and the use of the adulterated product in the manufacture of medicinal effervescent drinks or of cheap "lemonade."

Poisoning by oxalic acid and the oxalates is of very rare occurrence in France, while in England, Germany, and the United States several cases occur annually. Briand gives a table of 94 poisonings in France during the years 1825 to 1832; Flandin one of 200 cases in the years 1841 to 1844; and Tardieu one of 617 criminal

poisonings from 1851 to 1863. No case of oxalic-acid poisoning is mentioned in either of these tables. In England, according to Taylor, there were 527 poisonings, in which the nature of the poison was known, during the years 1837 and 1838, of which 19, or 3.6 per cent., were by oxalic acid. According to the "Reports of the Register-General of Great Britain" there were, in the year 1840, 138 suicides by poison, of which 2, or 1.45 per cent., were by oxalic acid; and during the years 1863 to 1867, 453 suicides by identified poisons, of which 58, or 12.8 per cent., were by oxalic acid. During the same years, 1863 to 1867, the total identified poisonings were 1,625, of which 66, or 4.06 per cent., were by oxalic acid. In the Berlin hospitals there were treated, according to Lesser and Schuchardt, from 1876 to 1878, 508 cases of poisoning, of which 24, or 4.72 per cent., were by oxalic acid. The reports of the New York City Board of Health for the years 1870 to 1875 show 84 accidental poisonings, of which 3, or 3.57 per cent., were by oxalic acid; and 231 suicidal poisonings, of which 4, or 1.73 per cent., were by oxalic acid.

The reason for the greater frequency of oxalic poisoning in England, Germany, and the United States is to be found in the very extensive use in those countries of oxalic acid and salt of lemon for household purposes, to clean metallic vessels and to remove ink- and fruit-stains from fabrics, as well as in the popular habit of "taking a dose of salts" at certain times of the year. Oxalic acid and magnesium sulphate resemble each other very closely in appearance, and hence the former is frequently taken by mistake for the latter.

Symptoms.—Oxalic acid is both a corrosive and a true poison, one or the other action predominating according to the size of the dose and the degree of concentration of the solution. If it be taken in the solid form or in concentrated solution, as is usually the case, the symptoms of corrosion, are the first to appear and may be the only ones observed. But if the poison be taken in dilute solution the symptoms of corrosion may be entirely absent.

In a typical case of oxalic-acid poisoning, the dose being in the neighborhood of fifteen grams (℥ ss.), taken in concentrated solution, the patient experiences the first effects of the poison either immediately, during the act of swallowing, or within a few moments. In exceptional cases the first appearance of symptoms has been delayed ten or twenty minutes, although larger doses were taken.

The strongly acid taste is observed and is followed by a sense of heat in the mouth, throat, and stomach. This rapidly increases in intensity until it becomes an intense, burning pain. In some cases the pain is accompanied by a sense of constriction of the throat and of impending suffocation. The act of swallowing is performed with difficulty, and, later, the voice becomes fainter and husky, and sometimes completely extinguished. Within ten or fifteen minutes violent and persistent vomiting begins in almost every case. The vomited matters are most frequently of a "coffee-ground" character, and separate on standing into two layers; the upper a clear, yellowish, and strongly acid liquid; the lower a thick, red-brown sediment of altered blood. Occasionally true hæmatemesis is observed. In cases in which the poison has been taken in small quantity and in dilute solution, the vomited matters may be free from blood. In some cases persistent vomiting and pain, and, later, persistent purging of a bloody material are the only symptoms, and they may continue, with or without intermission, for five, six, or seven days. Death finally occurs from exhaustion in from five to ten days.

When very large doses have been taken (30 to 60 grams = ℥ j.–℥ ij.), after vomiting, the patient may go into a state of collapse and die within five minutes.

The lips, mouth, and fauces are, shortly after the poison has been taken in solution, reddened, swollen, and painful. Later they become paler, and finally, sometimes within an hour, of a dirty, ashen-white hue, either throughout or in patches. The tonsils and uvula are much swollen. There is severe thirst.

Soon the symptoms due to the true poisonous action of the acid are added to those caused by its immediate corrosive action upon the alimentary canal. The countenance is pale, anxious, and haggard, the upper lip trembling, the lower jaw relaxed. The surface is bathed in a cold, clammy perspiration. The fingers are semiflexed and rigid, and the nails blue. The eyes are glazed and the pupils contracted. There is sometimes persistent hiccough. The pulse is small and thready, sometimes intermittent or imperceptible. There is general numbness and a sense of tingling or cramps in the upper and lower extremities. Abdominal pain is no longer complained of, although the abdomen may remain tender to pressure, but the patient suffers violent lumbar pains, shooting down into the lower extremities. The respiration is quick and labored. The skin in some cases is marked with an exanthem resembling that of roseola. The urine is frequently retained, and that removed by the catheter contains albumen in large quantity, epithelium, granular or hyaline casts, and crystals of calcium oxalate. Sometimes, in cases of recovery, the urine remains purulent for several weeks.

Sometimes there are violent spasms of a tetanic character; more rarely delirium. In cases of recovery, spasmodic twitchings may continue for a month.

In exceptional cases (usually, though not always, cases in which a small dose has been taken) the patient rapidly becomes stupid, somnolent, and unconscious. This condition has been known to pass into one of coma, terminating in death (Tidy: *Lancet*, 1872, ii., 41).

Like the mineral acids and alkalies, oxalic acid may cause death secondarily, after partial recovery, by starvation, due to extensive destruction of gastric and intestinal mucous membrane. This was observed in an early case by Fraser (*Edinb. Med. Journ.*, xiv., 1818, p. 607), in which death by inanition followed in fourteen days from the effects of a dose of ℥ ss. (15.5 Gm.) of the acid.

The immediate cause of death in oxalic-acid poisoning may be, therefore, either collapse, paralysis of the heart, or inanition.

Duration.—The duration of a case of oxalic poisoning is usually short if it terminate in death; but if the patient recover the case is generally protracted through several days. Of 22 cases ending in death, 9 died within half an hour, 3 in from one to twelve hours, 3 in from twelve to twenty-four hours, and 7 in from two to fourteen days. Of 14 cases terminating in recovery, in which the time of discharge is mentioned, 3 recovered within one day, 4 in from one to five days, 4 in from five to ten days, and 3 in from ten days to three months. The shortest recorded duration of a fatal case is three minutes, the longest fourteen days.

Lethal Dose.—The following tabulation of fifty-one cases will illustrate the difficulty of fixing this quantity definitely:

	Recovery. Cases.	Death. Cases.
Undetermined	5	11
4.00 grams = ℥ j.	1	1
7.75 " = (℥ ij.)	3	1
11.66 " = (℥ iij.)	1	1
15.50 " = (℥ iv.)	6	2
23.33 " = (℥ vj.)	0	2
27.22 " = (℥ vij.)	0	1
31.00 " = (℥ viij.)	7	7
38.85 " = (℥ x.)	1	0
46.65 " = (℥ xij.)	1	0
	25	26

From this it will be seen that one-half of those who have taken over four grams (℥ j.) have died; and that the deaths and recoveries are nearly evenly balanced with all doses below thirty grams (℥ j.).

Treatment.—The first indication, and one which admits of little delay, is the neutralization of the acid in such a manner as to bring about the formation of an insoluble oxalate, and thus prevent further corrosion and absorption. For this purpose the alkaline carbonates are useless, because, although they neutralize the acid and thus prevent further corrosion, the salts formed are soluble and as poisonous as the acid itself. The old direction to "scrape the wall" and administer the scrapings, was well enough so long as whitewashed walls were in vogue; but to administer the scrapings of a modern plas-

tered wall is of no benefit, as the sulphate of calcium so given is incapable of neutralizing oxalic acid, or of converting it into an insoluble salt. The best antidote is milk of lime, *i.e.*, lime-water holding a large excess of calcic hydrate in suspension, or a similar preparation of magnesia. The carbonates and bicarbonates of calcium, magnesium, sodium, and potassium are not to be recommended, owing to the volume of gas which they must necessarily generate if they be of any service at all; and for the further reason, in the case of the alkaline carbonates and bicarbonates, that although they may prevent the corrosive action of the acid, the oxalates which they produce are possessed of as actively poisonous qualities as the free acid. The use of the stomach-pump is distinctly contraindicated. Emetics are rarely called for, as persistent vomiting is one of the most characteristic effects of the poison. In the rare cases, however, in which vomiting does not occur as a result of the poisoning, emetics may be given, but only after early neutralization of the acid. In no case should warm water be given with a view to producing emesis; and, until the acid has been neutralized, the amount of liquid of any kind taken by the patient should be as small as possible. Opium may be given to allay pain, and stimulants in the stage of collapse.

Post-mortem Appearances. — The lips, tongue, mouth, and œsophagus are of an opaque, yellowish-white color, sometimes marked with patches of a reddish hue. The stomach is contracted, and in many cases contains a thick, gelatinous, reddish-brown and acid liquid, somewhat similar to the "coffee-ground" material vomited during life. The peritoneal surface of the organ, as well as the mesentery and the greater portion of the peritoneal surface of the intestines, are marked by blood-vessels filled with dark, fluid blood. The mucous surface of the stomach is strongly corrugated, and in most cases presents a uniform, bright red color in the elevations and depressions, except in so far as it may have been changed to brown, or even black, by post-mortem action. In some cases the mucous surface is, either in part or in whole, pale, opaque, or translucent, and marked with a coarse, ramiform vascularity of the submucous tissue. The mucous membrane, where it remains, is soft, pulpy, and easily detached. Although perforation has been observed, it is of rare occurrence. Crystals of oxalic acid, or of hydropotassic oxalate are not frequently found in the stomach, although Lesser figures a case (Atlas, t. viii., fig. 1), in which the patient died within ten minutes; and the almost uniformly pale and much contracted stomach was found plentifully lined with crystals of hydropotassic oxalate. Microscopic crystals of calcium oxalate are, however, found in many cases in the stomach and intestines, particularly in cases in which death has followed, not within a few moments, but in the course of from three to six hours. A microscopic examination of a section of kidney reveals the presence of amorphous and crystalline oxalate in the tubules, even in rapidly fatal cases (Lesser, l.c., t. vii., fig. 3).

Analysis.—The parts to be examined are the stomach and intestines and their contents, the liver, kidneys, and urine; also vomited matters.

The contents of the stomach and the vomited matters are strongly acid in reaction, unless antidotes have been administered, in which case they may be neutral, or even alkaline.

In a systematic analysis the acid, or its salts, are to be found in the residue of the portion examined for prussic acid and other volatile poisons, or in the aqueous liquid which has been treated with solvents for the separation of glucosides and alkaloids. If oxalic acid or oxalates alone are to be sought for, the materials are to be treated directly as below.

It must be remembered that the acid sought may be present either in the free state, in combination as a soluble oxalate, or, in consequence of the administration of antidotes, as the insoluble oxalate of calcium, or the very sparingly soluble oxalate of magnesium.

The substance under examination, if acid, is to be first extracted with water, the solution filtered, the filtrate evaporated over the water-bath, the residue extracted with alcohol, the filtered alcoholic solution evaporated, and the residue redissolved in a small quantity of water. The solution so obtained (No. 1) will contain any free oxalic acid which may have been present. The material left undissolved by alcohol in the preparation of solution No. 1. is next to be extracted with alcohol, acidulated with hydrochloric acid, the solution filtered and evaporated, and the residue redissolved in a small quantity of water. This solution (No. 2) will contain any oxalic acid which may have been present in the form of a *soluble* oxalate. Lastly, the substance left undissolved by water in the preparation of solution No. 1 is to be treated with a sufficient amount of solution of carbonate (not hydrate) of potassium to render it distinctly alkaline, and boiled for two hours. The solution is filtered and evaporated, the residue extracted with alcohol acidulated with hydrochloric acid, the solution filtered and evaporated, and the residue redissolved in water. This solution (No. 3) will contain oxalic acid, if it were present, in the form of an *insoluble* oxalate.

The tests for oxalic acid are then to be applied to the three solutions.

The urine, contents of stomach, and vomited matters should also be examined microscopically for crystals of calcium oxalate.

The detection of a *mere trace* of oxalic acid can only be of value as corroborative evidence in a case of suspected poisoning by that substance, owing to the normal presence of oxalates in articles of food and in the human economy.

Tests.—1. A solution of a calcium salt produces, in neutral or alkaline solutions, a white precipitate which redissolves in hydrochloric acid.

2. Argentic nitrate solution produces a white precipitate which dissolves in ammonium hydrate solution and also in nitric acid. If the liquid containing the precipitate be boiled, the latter does not darken. If the precipitate be collected, dried, and heated upon a strip of platinum foil, it explodes.

3. Lead acetate solution, in solutions of oxalates which are not too dilute, produces a white precipitate which is soluble in nitric acid, but insoluble in acetic acid.

R. A. Witthaus.

OX GALL (*Fel Bovis*, U. S. Ph.; *Bile de Boeuf*, Codex Med.). The gall of the domestic ox, *Bos Taurus* Linn., taken from the gall-bladder soon after killing, and used or purified at once. "A brownish-green or dark green, somewhat viscid liquid, having a peculiar odor, a disagreeable, bitter taste, and a neutral or faintly alkaline reaction." For medicinal use the crude Ox Gall is further prepared either by simple evaporation or by purification. The following methods are officinal:

1. Inspissated Ox Gall (*Fel Bovis Inspissatum*, U. S. Ph.), made by heating it to a moderate degree ("not exceeding 80° C. [176° F.]"), straining and evaporating to fifteen per cent. of its original weight. It is an extractiform mass of suitable consistence for pills.

2. Purified Ox Gall (*Fel Bovis Purificatum*, U. S. Ph.; *Fel Bovinum Purificatum*, Br. Ph.) is made by evaporating the crude Ox Gall to one-third, mixing with an equal quantity of alcohol, allowing the mixture to stand for coagulation of mucus, etc., and then decanting, filtering, and evaporating to a soft solid. The preparations are essentially duplicates of each other, or, at least, the latter has all the advantages of the other besides that of the separation of the useless part precipitated by the alcohol. Purified Ox Gall is thus described in the Pharmacopœia: "A yellowish-green, soft-solid, having a peculiar odor, and a partly sweet and partly bitter taste. It is very soluble in water and in alcohol. A solution of 1 part of Purified Ox Gall in about 100 parts of water behaves toward sugar and sulphuric acid as the solution mentioned under Ox Gall.* The aqueous solution of Puri-

* *I.e.*, ten grams of it, when treated with one drop of a twenty-per cent. aqueous solution of sugar, and then with sulphuric acid cautiously added . . . gradually acquire a cherry-red color, changing successively to carmine, purple, and violet.

fied Ox Gall should yield no precipitate on the addition of alcohol."

Composition.—This complex substance in its crude condition consists of about ten per cent. of solids and ninety of water. The most important solid constituents are the *sodium salts* of *taurocholic* and *glycocholic acids* and several not very well distinguished coloring matters (*bilirubin, biliverdin*, etc.). Besides these it also contains a number of decomposition products, *cholesterin, urea*, etc., and some *fats* and *mucus*.

Action and Use.—Without going elaborately into the action of bile, it may be said that Ox Gall appears to quicken the absorption of fats and to increase peristalsis. In this latter way it acts as a mild laxative. It may also prevent, in some degree, the decomposition of the intestinal contents. It does not assist in the digestion of starchy food, however, and it distinctly interferes with stomach (peptic) digestion. This medicine is, therefore, indicated in constipation with intestinal dyspepsia and mal-assimilation of fat. In gastric dyspepsia it ought to be injurious, and is occasionally irritating. It is, on the whole, seldom that other remedies will not entirely fill its place, and, although an old remedy and long tried, it had fallen nearly out of use until recently. It will, probably, soon be again obsolete.

Administration.—The purified preparation, which is the one to be used, may be made into pills or a bolus. Dose from five to ten centigrams (½ to 1 Gm. = gr. viij. ad xv.). "Cholate of Sodium," an impure preparation of the biliary salts, is to be had, dose from one-third to one-half as much as the former. Brunton recommends a coating of *keratin* to prevent the solution of the pills in the stomach.

Allied Drugs.—Pancreatin is also used for intestinal indigestion. Salines and the resinous laxatives are generally given in conditions similar to those mentioned as indicating Ox Gall. *W. P. Bolles.*

OXYGEN. Oxygen is not recognized in the U. S. Pharmacopœia as a drug, but is yet used in medicine to a certain extent, generally by inhalation, either of the pure gas, or of the same mingled with from one to four volumes of atmospheric air or of nitrogen monoxide (nitrous oxide gas). Oxygen is a colorless, odorless, and tasteless gas, and is, when pure, distinctly irritant to sensitive parts. Its main medical interest centres upon the phenomena which follow the inhalation of the gas in greater concentration than is the case in the atmosphere. Continuously inhaled, pure, the irritant effects of oxygen are considerable; mice immersed in an atmosphere of pure oxygen die after three days with congested and inflamed lungs. With inhalations too short to excite local mischief, the question naturally arises whether an atmosphere abnormally rich in oxygen does or does not tend to determine abnormal absorption of the gas into the blood, and so a quickening of the oxidations concerned in vital processes. Opposite opinions have been held on this question. The one view (Regnault and others) is that with healthy lungs the blood normally takes from ordinary atmosphere all the oxygen that it is physiologically capable of absorbing, so that the presentment to it of an air containing an increased proportion of the gas can have no effect on the absorption rate. But a considerable number of experiments and observations of various kinds seem to oppose this view, and lead to the belief that crowding the lungs with oxygen does also crowd the blood with the gas. Thus, during oxygen inhalations granulation-tissue has been observed to grow quickly ruddier in hue (Demarquay), expired carbon dioxide to double in amount (Allen and Pepys, Limousin), and excreted uric acid to lessen in quantity, presumably by undergoing oxidation within the system (Kollman). Whichever answer to the question be the true one, no marked symptom pointing to any serious derangement of physiological processes occurs when a moderate inhalation is practised by one in health. The gas, even when pure, is pleasantly respirable, and from fifteen to thirty litres (from four to eight gallons, about) can be inhaled with little other obvious effect than a feeling of general warmth and nervous exhilaration, with occasionally a little giddiness and quickening of the pulse-rate. But while the effects in health are comparatively negative, it is far otherwise when an oxygen inhalation is undertaken by one suffering for want of a sufficiency of oxygen because of some impediment to the full exercise of the respiratory function, such as may be caused by asthma, emphysema, cardiac disease, croup, diphtheria, etc. In such case the distress, because of the insufficiency of the air-supply, tends to be compensated by the higher oxygenation of the same, and the dyspnœa may be greatly abated, or even, for the time, wholly abrogated. And the relief may persist, of course in keeping with the character of the case, for a longer or shorter time after discontinuance of the inhalation. Similar relief by respiration of oxygen is afforded in cases of asphyxia from irrespirable or noxious gases, such as carbon monoxide or the poisoned air of sewers.

The therapeutic applications of oxygen are, first in importance, the administration of the gas by inhalation for the relief of dyspnœa or asphyxia in the circumstances above described. Inhalations have also been practised with the view of quickening the processes of physiological chemistry and so determining better nutrition in chronic cachectic states, such as anæmia, chlorosis, tuberculosis, etc. The results of this latter therapeusis have not, however, been very striking. Under any circumstances the existence of ulceration or active inflammation within the air-passages had better be accepted as contraindicating oxygen-inhalation, unless the gas be well diluted. In appropriate cases, from four to sixteen litres (one to four gallons, about) may be inhaled at a sitting, two or three times a day, pure or diluted with air, from one to four volumes, according to the urgency of the case. The gas must be known to be pure, in the chemical sense of the word, and is best administered by means of the bags devised for the giving of nitrous oxide gas. But whether the gas be drawn from a bag or from a gasometer, the inhalation should be by means of a mouthpiece so fitted with valves as that the products of expiration shall not pass into the apparatus to mingle with the gases to be respired. In order to obtain dilution with air the simplest expedient is to leave the nostrils open to inhale the atmosphere, while the mouth inhales oxygen.

Oxygen has also been used locally for the vivifying of tissues disposed to ulceration or gangrene, with reported benefit. The practice is certainly not a common one in the United States. The gas is applied in jet upon the affected parts.

Oxygen is supplied for medical use in iron cylinders, generally condensed so that a cylinder holding from one hundred to two hundred gallons is of a size easily handled and stored. From such reservoirs a bag or gasometer is charged for the individual inhalations. Where these cylinders are not procurable, oxygen may be obtained by the usual procedure of heating potassic chlorate with admixture of a little manganese dioxide—this addition in some way determining the decomposition of the chlorate at a lower temperature than would otherwise be required. The manganese compound must be free from adulteration with carbon (such as occurs in some commercial samples by the accidental or intentional addition of pounded coal), else a dangerous explosion may result. It is best, therefore, to test an untried sample by heating a little of it with a little potassic chlorate in a test tube, where the small scale of a possible explosion will do no serious mischief. For the making, the mixed substances are heated in a closed retort or flask, from which a tube leads through an intervening wash-bottle, containing caustic soda solution, to a gasometer or jar filled with water and inverted in a pneumatic trough, or to the bag from which the inhalations are made. The first portions of gas that come over should be allowed to escape before connection is made with the wash-bottle. And this wash-bottle is an all-important feature of the apparatus, the passage of the oxygen through soda being necessary to free the gas from contamination with carbon dioxide and chlorine. The connecting tube of the apparatus should

be of good size, since the gas, when once it begins to disengage, comes over in great volume. For the same reason the heat should be carefully watched and regulated during the operation, to avoid too furious action. For each litre (about one quart) of oxygen required, 3.46 Gm. (about fifty-three and a half grains) of potassic chlorate will be needed. The salt must be well powdered, and mixed with one-eighth of its weight, or thereabouts, of powdered and pure black oxide of manganese.

Edward Curtis.

OZÆNA, from ὄζειν, to stink, or ὄζαινα, a fish possessing a fetid odor. Synonyms: Fetid Catarrh, Scrofulous Ozæna, Fetid Coryza, Strumous Catarrh, Stinknase (Ger.), Punaisie (Fr.), Fœtor Narium, and Dysodia Narium (Lat.).

Definition.—By true or simple ozæna (rhinitis chronica atrophicans fœtida), names preferred by the writer, is meant an affection limited to the nares, in which there is no ulceration or diseased bone, the fetid odor depending on changes in the retained secretions.

The disease, of course, may be modified by diathesis, but is not dependent thereon.

Preliminary Remarks.—The above names are applied to a condition of the nares in which a stinking, and, to some extent, characteristic odor is exhaled. This odor is *sui generis*, but has been improperly likened to the peculiar smell of a mashed bedbug or chintz.

There exists considerable ambiguity concerning the application and exact significance of ozæna, and although originating in the earliest period of medicine the word has acquired a large and rather indefinite use, even in modern times.

Brochin prefers to describe the condition as an infirmity, not esteeming it a disease proper.

The term, when unqualified, is quite as indefinite and vague to a scientific mind as the generic expressions pain, fever, inflammation, or dropsy; all of which phenomena may owe their existence to diverse causes.

A mere stench exhaled from the nares may originate from disease of the accessory sinuses, from rhinoliths, from the presence of some external foreign body, from disease of the osseous or cartilaginous framework, from cancer, from lupus, from syphilis, and other causes, but the ozæna (stench) is symptomatic only of these disorders.

Until very recently any affection of the nasal passages in which the expired air was fetid was called ozæna; hence, diseases differing widely as to symptoms, course, and treatment were included under this rather broad category.

The writer fails to appreciate in what manner limiting the word ozæna to those fetid diseases of the accessory sinuses whose prominent symptoms are manifested in the nares, can lead to a simplification of the question.

The retention, then, of this word in medical nomenclature is unfortunate, and its use, except as hereafter to be indicated, calculated to promote confusion.

Ozæna is by no means to be classed as a separate and distinct disease, but rather as an attendant of several nasal affections, particularly atrophic rhinitis.

The writer further believes that ulceration of the nasal mucous membrane rarely, if ever, occurs in true ozæna, and he considers the retention and decomposition of nasal secretions an essential factor in the production of the stench accompanying the affection.

Clinically, he is satisfied that the fetidness of the odor is proportionate to the length of time the incrustations remain in the nasal cavities.

In the present contribution he will, so far as is consistent with fact, have respect for the above indicated propositions, which are briefly the expression of his individual views concerning this unsettled question.

Historical.—Well-nigh all ancient writers considered ozæna as associated with, and dependent upon, the presence of ulcers within the nares.

Celsus (40 B.C. to 20 A.D.) says, "The Greeks gave the name ozæna to nasal ulcers covered with crusts of a stinking odor."

Galen (second century) defines ozæna as "an ulceration in the depths of the nostrils causing a discharge and a bad odor."

Both Pliny (first century) and Ætius (fifth century) speak of the therapeutic management of ozæna, the latter recommending for its cure insufflations of various medicaments, and also the introduction of medicated pledgets within the nostrils.

The treatment instituted by Rufus (second century), Rhazes (ninth century), Avicenna (tenth century), Forestus (sixteenth century), and others, was, primarily, detergent, and, secondarily, directed to drying up the ulcers.

Actuarius (fourteenth century) seems not to have regarded ulceration as a constant accompaniment of ozæna, but calls especial attention to the odor emitted from decomposed nasal secretions.

Alexander Trallianus (sixth century) and Paré (sixteenth century) entertained essentially the opinions promulgated by Galen at an earlier period, while Fabricius ab Acquapendente (sixteenth century) and Thomas Mayern (seventeenth century) thought syphilis the leading *causa morbi*.

Reininger (1722) and Günz attributed ozæna to the putrefaction of secretions retained in the frontal, ethmoidal, sphenoidal, and maxillary sinuses, a theory which has been urged more recently by Michel and Rouge.

Sauvages (1771) was, I find, the first to insist upon the distinction of ozæna without lesion of the nares (simple, true, or idiopathic ozæna) from that attributable to lesions of the nasal mucosa, the nasal bones, and cartilages.

Valleix (1866) did not attribute ozæna to an ulceration of the Schneiderian membrane.

Cloquet (1830), Trousseau (1835), Cazenave (1835), and other older writers, have described the leading clinical features of ozæna with a clearness and scientific accuracy worthy of admiration.

Trousseau (1835), Max-Simon (1850), and Cousin (1868) divided the disease into symptomatic and constitutional ozæna.

In 1866 Otto Weber maintained that ozæna was simply a symptom and not a distinct disease, as many had hitherto claimed.

Niemeyer (1874) thinks there is an ulcerative and a non-ulcerative ozæna.

A very remarkable monograph has recently been published (1886) by W. Moldenhauer, in which the opinions and teachings of Gottstein, B. Fränkel, Bresgen, and others, are warmly assailed.

Moldenhauer himself, however, makes no attempt to explain the pathology of true ozæna, or to add another to the many theories already existing relative to this affection.

During the past six years interesting articles upon this disease have been written by Schrötter, Zaufal, Tillot, Zuckerkandl, Michel, B. Fränkel, Gottstein, Schäffer, Rouge, Cozzoline, Stoerk, Beverley Robinson, Martin, Bosworth, Franks, Krause, Massie, Calmettes, Moure, Ziem, Clinton Wagner, Woakes, Thornton, Morell Mackenzie, and others, reference to which is made in my bibliography of this subject at the end of the article.

Etiology.—True ozæna is usually associated with an atrophic rhinitis, and occurs most frequently prior to the age of thirty, and oftener in the female.

The disease is common in children, and sometimes exists in two or more members of the same family, but proof of its contagiousness is wanting.

Atrophic rhinitis with ozæna is, according to most authorities, generally due to the manifestations of the scrofulous or syphilitic diathesis upon the Schneiderian mucous membrane.

The nasal fossæ are richly supplied with glands and lined with tissues of a highly vascular and cavernous structure, thus offering the conditions necessary for the localization of either scrofula or syphilis therein.

The ozænic subject is one who usually suffers from a constitutional weakness, at times ill-defined, which may be occasioned by heredity (Fränkel, Zaufal, and Bresgen), by hereditary syphilis, by scrofula, or occur as a sequel of the eruptive fevers, particularly of scarlatina, measles, and small-pox.

We are struck with the similarity, as to age and general surroundings, of patients suffering with this disease; they are about the age of puberty, the youngest may be nine, the oldest is generally not over twenty years of age. Adults will invariably trace their disease back to early life.

The contour of the nose in children suffering with ozæna is frequently identical with that of their parents (father or mother) who have the same affection.

M. Mackenzie does not regard the disease as constitutional in the true sense of the word. He further says "that though scrofula probably produces a certain disposition to catarrh, and renders the affection more intractable when it does occur, it cannot, in my opinion, be said to cause ozæna."

Ziem and Schaffer claim that true ozæna may occur independently of atrophic rhinitis, and we all well know, on the other hand, that atrophic rhinitis is not invariably accompanied by ozæna.

Among Schäffer's 123 cases of ozæna, 99 were due to struma and 20 to syphilis.

Stoerk maintains that syphilis is the sole cause of ozæna.

Gottstein says that only two of his twelve cases of ozæna appeared to result from scrofula, and none was traceable to syphilis.

The existence of what may be denominated true ozæna, as distinguished from the symptomatic variety (dependent upon caries, necrosis, polypi, deformities, abscess of the accessory sinuses, etc.), appears to be established not only clinically, but anatomically and etiologically.

The rhinoscopic and post-mortem examinations made by Zaufal, Michel, Hartmann, Gottstein, and other German investigators, have rendered it quite evident that the peculiar fetid odor of true ozæna has no dependence upon the presence of ulceration in the nares; that when the adherent crusts are removed the pituitary membrane is seen to be less vascular than normal, smoother, slightly atrophied and inflamed, but above all intact.

The turbinated bodies do not present the characteristic erectile prominence; the inferior one is of diminutive size and is sometimes absent, giving to the nasal cavity enormous dimensions.

Chronic rhinitis, especially of the hypertrophic variety, predisposes to the development of atrophic rhinitis, and perhaps of a subsequent true ozæna.

The inhalation of dust and irritating gases, deviations of the vomer, and other conditions causing a chronic rhinitis, may result in ozæna.

The exceedingly disagreeable odor of ozæna is thought by a few authors to arise from individual idiosyncrasy, just as foul perspiration of the axillæ, groins, and feet is common to some individuals.

The penetrating perfume emitted from the body of the average negro is a striking instance of race idiosyncrasy, and exceeds in rare cases the nauseating exhalations of ozæna.

That the nasal mucous membrane in ozænic patients is endowed with the special function of exhaling or secreting foul odors, the writer does not believe.

Bosworth very aptly remarks in this connection that there is no analogy in the above comparisons, as the nasal mucous membrane is not an excretory organ.

It is the writer's opinion that the foul odor in true ozæna is dependent solely upon the presence of retained and decomposing secretions within the nares; and that if these secretions be removed and their further formation checked, all fetor disappears.

To the assertions that ozænic secretions contain a special ferment, and that ozæna is attributable to fatty metamorphosis, he attaches slight importance clinically.

Recently Loewenberg has added an interesting monograph to the already voluminous literature of this affection, and claims to have discovered a special microbe (always found as a diplococcus) for ozæna.

Around this microbe clusters much that is ingenious, theoretically, but the practical results of the alleged discovery as regards the cure of ozæna are as yet nil.

It has been stated that ozænic patients never suffer from hay fever; but the writer happens to know of one at least who does.

Anosmia, however, appears to afford complete immunity from hay fever, so far as is now known.*

Pathology.—The disease, as stated, commences generally in early life, and according to Bosworth "in an inflammation which is characterized by a desquamation of the epithelium lining of the acinous glands, which results in their destruction."

In some of Bosworth's specimens the glands had disappeared absolutely. The result of this is necessarily that the membrane is deprived of its normal supply of mucus. That which is secreted being scanty, very soon dries upon the surface of the membrane. There is thus formed a dry pellicle, which adheres closely, and is removed with difficulty. Remaining, it soon undergoes decomposition, and gives rise to fetor.

The pellicle of inspissated muco-pus which dries upon and adheres to the membrane, clinging about the convexity of the turbinated bones, and contracting and drying, necessarily exercises pressure and obstructs the circulation.

As a result of this, the atrophy of the membrane is still more encouraged. As we know, the deep layer of the mucous membrane in this region blends with, and really forms, the periosteum of the turbinated bones. We can easily see, therefore, how, as the result of the process continuing through years, there may occur the atrophy of the turbinated bone which characterizes the late stages of the disease, and which results from impaired nutrition.

Zuckerkandl, as quoted by M. Mackenzie, proves that not only the soft tissues, but also the bony structure of the turbinated bodies become thinner, more elastic, flatter, and smaller.

"The mucous membrane shrinks and becomes wrinkled, the erectile tissue disappears, and the thin, pale, shining mucosa looks more like serous than mucous membrane.

"When the morbid process is far advanced nothing is left but thin bands of mucous membrane, occasionally perhaps containing some small osseous fragments, the remains of the spongy bones."

Gottstein, as quoted by the same author "finds no defect other than a certain thinness of the mucous membrane in cases of ozæna. On microscopic investigation the epithelium was found to be normal; beneath this was a layer of small round cells mixed with a few spindle-shaped cells, and beneath this stratum again was another of fibrillar areolar tissue generally lying parallel to the surface, the fibrillæ being here and there collected into bundles in different stages of development. The vessels were richly developed and the elastic tunic of the arteries thickened. The glandulæ were numerous, the gland cells not being recognizable in some places, and the appearances were those of chronic rhinitis with more or less advanced cirrhosis of the mucous membrane and a partly infiltrated and atrophied condition of the glandulæ."

Zaufal thinks the small size of the turbinated bones is not due to atrophy, but to arrested development.

Zuckerkandl, by an examination of two hundred and fifty-two skulls, has apparently disapproved Zaufal's views.

The discharges and crusts of ozæna consist of pus-corpuscles, granular débris, and some epithelium, and are usually of an alkaline reaction.

Krause contends that the mucous cells undergo fatty degeneration, and says he has found in the secretion of ozæna fatty corpuscles and pigmentary molecules, which form a part of the tenacious crusts.

Quite recently Habermann, of Prague, finds that true ozæna consists in an affection of all the glands; first there is an accumulation of drops of fat in the glandular epithelium, and later a complete degeneration of the epithelium takes place.

At a later stage there is inflammatory infiltration of the mucous membrane with granular degeneration of the infiltrated cells, while at certain points the drops of fat already described by Krause are observed.

* See writer's remarks, Trans. Am. Laryngological Association, 1886.

The osseous structures and venous sinuses alike suffer atrophy.

Moure, of Bordeaux, inclines to the opinion that the atrophied turbinated bodies in true ozæna are regenerated as the patient advances in age or as the disease diminishes in severity under treatment.

Symptoms.—To the intelligent and frequent performance of *anterior* and *posterior rhinoscopy* much that is accepted at the present day concerning the diagnosis, symptomatology, and proper treatment of rhinitis chronica atrophicans fœtida (true ozæna) is directly attributable.

With the aid of the rhinoscope we are enabled to note every change in *objective symptoms* resulting from treatment or otherwise, and can readily assure ourselves of the special points at which mucous collections are wont to lodge, and thus are able to effectually remove the same.

Rhinoscopy generally demonstrates the presence of dried mucus, fetid crusts, and capacious nasal chambers dependent upon the smallness or entire absence (?) of the inferior turbinated bodies, all of which are briefly the salient features of true ozæna.

The crusts are often found distributed over the entire surface of the nares, more commonly, however, moulded over the middle turbinated bones, post-nasal orifices, and pharyngeal vault. The morbid changes giving rise to fetor in true ozæna appear to be confined to the narrower portions of the nares, the pharyngeal vault habitually escaping.

The *constitutional symptoms* of ozæna, when present, are those pertaining to the particular diathesis with which ozæna is associated, namely, scrofula, syphilis, or tuberculosis.

Fig. 2731.—Profile of a Child of Twelve Years, suffering from True Ozæna. (Writer's case.)

Dyscrasia and general systemic disturbance, perhaps illy defined, are nearly constant accompaniments of ozæna, and if not present from the incipiency of the disease, appear at a later stage.

We have all encountered atrophic rhinitis with ozæna in apparently healthy children and adults, but such a state of health is exceptional and not destined to be of long duration, for the mere inspiration of tainted air by such a patient will finally result in impairment of his general health. The facial expression and shape of the nose is quite characteristic in many ozænic patients; we have the strumous facies, thick lips, prominent cheeks, submaxillary glandular enlargement, the bridge of the nose is depressed near the frontal bone, the anterior nasal orifices, instead of opening downward, often look outward anteriorly.

The saddle nose is Zaufal's name for the above state of affairs. Fig. 2731 represents the profile of one of my ozænic patients.

The shape of the nose appears to have had great influence with the Emperor Nicholas, of Russia, in selecting his famous regiment, "the Imperial Nosegay."

Before the Crimean war he discovered by some means that the best fighting and most ferocious men possessed a nose which stood straight out from the base of the forehead in the form of a triangle, presenting in front the appearance of a double-barrelled pistol.

This crack regiment of a thousand men was ultimately routed by the French, and the defeat was attributed to a peculiar sensibility of the nose regiment for garlic, of which the Frenchmen are so fond and had eaten, and with the odor of which the atmosphere of the battle-field was loaded.

When charged with cowardice, "the Imperial Nosegay" said they could and would face any foe; but the odor of the garlic-eating Frenchmen was too much for them.

Antecedent history frequently affords no clue to the existence of diathesis in these patients, and they are often entirely ignorant of their nasal affection until those associated with them perceive the stench. It is proper to state again at this point that several authorities consider ozæna a local disease, entirely independent of diathesis.

The foul-smelling exhalation occasioned by ozæna is the most prominent symptom, and frequently renders the patient a burden to himself and an object of avoidance by those brought in contact with him. Patients are occasionally totally unconscious of these foul emanations, for the reason that olfactory sensibility is blunted by either atrophic changes or the ever-present odor.

When the discharges are copious and there is the characteristic incrustation and tenacious adhesion of scabs to the nasal membrane and turbinated bodies, the breath becomes particularly offensive, even saturating the air of an ordinary room with the foul odor. The writer on several occasions has been forced to exclude ozænic patients from

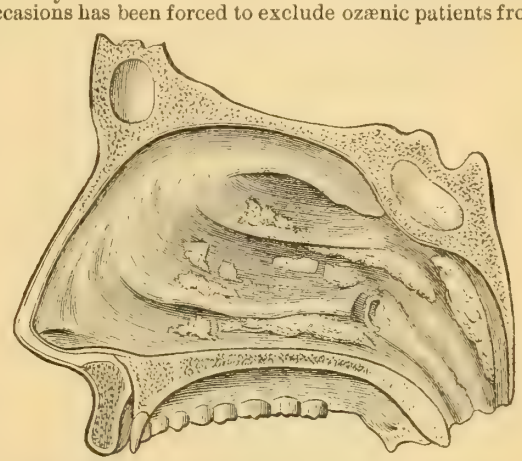

Fig. 2732.—Sites generally occupied by the Crusts of True Ozæna, as revealed by Anterior and Posterior Rhinoscopy. (Writer's case.)

his reception-room and treat them at special hours, so objectionable was their presence to other patients.

The crusts are of a greenish or grayish-brown color, often streaked with blood; they accumulate in both the anterior and posterior nares and the naso-pharynx, causing great embarrassment to nasal respiration, and frequently occasion nausea and vomiting when the patient makes an effort to dislodge them. Frontal and supraorbital pains, anorexia, depression of spirits, perverted taste, loss of smell, and dulness of the mental faculties are common symptoms.

The olfactory sense may be partially or entirely lost, and the disorders of taste resulting therefrom may seriously interfere with nutrition, by rendering certain foods (meats) distasteful.

M. Martin recognizes, in common with Zaufal, that slight functional disorder of the ear, and perhaps otitis, may occur as a complication of ozæna, as of other nasal affections. According to Loewenberg, the immunity of the middle ear in this affection is wellnigh universal. Catarrh of the lachrymal canal, epiphora, catarrhal conjunctivitis, and weakness of the eyes are among the complications of the disease under discussion.

There is usually considerable irritation and dryness of the pharynx, and its membrane is generally either covered by a thin pellicle of dessicated secretion, or is of a dry, glistening appearance if the crusts have been previously detached.

The number and size of the crusts discharged vary greatly; they are not usually larger than an almond-shell, and one is usually discharged every few days from either nostril. I have known, however, two crusts of large size to escape daily from each nostril.

The velum pendulum palati is almost universally deprived of its normal sensibility, and a posterior rhinoscopic exploration can be readily accomplished.

Such an examination, as before indicated, shows that the mucous membranes are everywhere pale, covered here and there by inspissated tenacious mucus, and that the soft tissues adhere closely to the underlying osseous structures, thus giving to the posterior nares an abnormally large appearance.

Figs. 2732 and 2733 are drawings made from one of my patients suffering with true ozæna, and show the points at which crusts are usually found, as revealed by anterior and posterior rhinoscopy.

Fig. 2733.—Posterior Rhinoscopic Image in a Case of True Ozæna (Writer's case.)

The atrophied condition of the nasal mucosa and thinness of the turbinated bones is also well marked in this typical case.

Diagnosis.—The diagnosis of "true ozæna," *i.e.*, atrophic rhinitis with fetid secretions, is both important and devoid of serious difficulty, if the modern methods at our disposal for exploring the nares be utilized. After thoroughly cleansing the nostrils of all crusts and mucosities by means of a detergent spray or douche, containing, preferably, Dobell's solution,* a careful anterior and posterior rhinoscopic examination is to be made, when, if ulceration, necrosis, polypi, foreign bodies, etc., are present, they can hardly be overlooked. The general history of our patient, and the persistence of fetor in symptomatic ozæna, after freeing the nares of accumulated secretion, must be kept in mind.

Several cases of symptomatic or simulated ozæna, due to the presence of plum-stones, cherry-stones, buttons, pebbles, etc., have been reported by Holmes, Coote, Tillaux, and others.

The extraction of the foreign body in these cases was followed by cessation of the symptomatic ozæna.

Prognosis.—Cases of true ozæna do not apply for treatment until the disease has existed quite a length of time, and is well established. Hence a cure is wrought with many difficulties, and can only be attained, if at all, by a persistent and long-continued therapeutic, hygienic, and dietetic régime. The writer firmly believes in the occasional curability of true ozæna.

The prognosis depends greatly upon the state of the patient's general health, his age, occupation, etc. If there is a marked scrofulous diathesis, we can materially mitigate the severity of the nasal symptoms, as well as contribute much toward rendering the ozænic manifestations comparatively endurable, but this is the extent of our present ability.

The disease is obstinate in the extreme, but grows less and less apparent as the patient advances in age; and the writer has seen it practically disappear at the age of forty.

While we are unable to achieve brilliant results in always curing ozæna, our numerous and efficient palliative methods may practically reduce the inconvenience of our patient to a minimum and result in great improvement of his general health. Systematic cleansing and disinfection of the nares deprives the inspired air, which is otherwise tainted and laden with decomposed effluvia, of its toxic influences, thus improving the general health.

During the writer's professional experience he has been called upon to treat several obstinate and aggravated cases of ozæna occurring in young ladies, circulating constantly during the season in the captivating social festivities of the capital of the nation. The daily dissipations of these belles were never interrupted, and their infirmities, thanks to science, have never been the subjects of suspicion. This favorable state of affairs, it is but fair to state, was only secured by the most assiduous use of detergent and antiseptic medicaments—such assiduity as highly sensitive persons would gladly avail themselves of to cover their repulsive infirmity.

Treatment.—The *treatment* of true ozæna is both *systemic* and *local*.

Systemic treatment should consist of tonics and alteratives administered in such manner and at such times as to improve the tone of the system and of the assimilative functions. For the anæmia attending ozæna, the preparations of arsenic, quinine, iodine, or iron, such as the tincture of the chloride, the syrup of the phosphates of iron, quinine, and strychnine, or bismuth, the mistura ferri composita (Griffith's myrrh mixture), or the syrup of the iodide, should be employed. Donovan's, Pearson's, or Fowler's arsenical solutions, as well as Lugol's iodine solution, are at times required by the exigencies of the case.

The writer has obtained excellent results from gold chloride, or gold and sodium chloride, $\frac{1}{60}$ to $\frac{1}{8}$ gr. three times daily. Where there is debility, loss of appetite, and emaciation, the syrup of the hypophosphites or lactophosphates of lime, sodium, potassium, or iron, either singly or combined, will be of service. Cod-liver oil, malt extracts, hydroleine, oleo-chyle, or, above all, a palatable preparation containing cod-liver oil, long used in the District of Columbia, the formula for which is herewith given, may render valuable service.

Mistura Phosphatica (*D. C. P.*).

℞.	Dilute phosphoric acid	f ℥ jss.
	Yolk of eggs	℥ iij.
	Cod-liver oil	f ℥ viij.
	Glycerine	f ℥ ijss.
	Oil of bitter almond	♏ xx.
	New England rum	f ℥ viij.
	Orange-flower water	q. s.

Reduce the yolk to a smooth paste; add gradually the oils with constant trituration, then add eight fluidounces of orange-flower water during brisk agitation. Lastly, add the glycerine, rum, phosphoric acid, and enough orange-flower water to make the finished emulsion measure thirty-two fluidounces.

Where, in addition to the above symptoms, there is a well-defined strumous diathesis and special impairment of the digestive functions, the writer has obtained excellent results from the following formula, which he devised some years since, and which is now in general use in treating tuberculosis and other wasting diseases:

Pulvis hypophosphitum cum Pepsino (*Morgan*).

℞.	Calcium hypophosphite	5 parts.
	Sodium hypophosphite	5 "
	Iron hypophosphite	2 "
	Manganese hypophosphite	1 part.
	Pepsin (Boudault's neutral)	8 parts.
	Milk sugar	4 "
M.		

This powder should be finely ground and kept, as well as dispensed, in glass. It can be prescribed in bulk, one-half teaspoonful (15 grs.) three times daily, stirred in cold milk, wine, water, brandy, etc. Lactopeptine, ingluvin, scale pepsin, or Scheffer's pepsin may be substituted in the formula for Boudault's pepsin. The preparations of mercury and potassium iodide are indicated when this disease is complicated with a syphilitic diathesis.

Climate appears to exert little influence on this disease. Abundant exercise, proper ventilation, avoidance of exposure, and perhaps sea-bathing, assist in bringing about a favorable termination of the affection.

Mineral waters, especially the sulphuretted, according to some writers, are beneficial when used either internally or locally.

* See correct formula, under Treatment, in this article.

There is urgent need of further investigations upon this point.

Clothing, etc.—The body should be warmly and comfortably clad, and every attention paid to the maintenance of cleanliness and of perfect action of the cutaneous and renal secretory functions.

Diet.—A well-regulated and sustaining system of diet, having due regard to proper action of the intestinal tract and the maintenance of bodily strength, is of first importance in managing the disease.

Local Treatment may be carried out by means of sprays, vapors, solutions, powders, ointments, medicated bougies, or cotton-wool tampons, medicated cotton, galvano-cautery, etc., and the objects sought to be obtained are: 1, the detachment of crusts; 2, their removal from the nares; 3, the correction of the fetid exhalations; 4, the prevention of crust formation, which latter amounts to curing the disease.

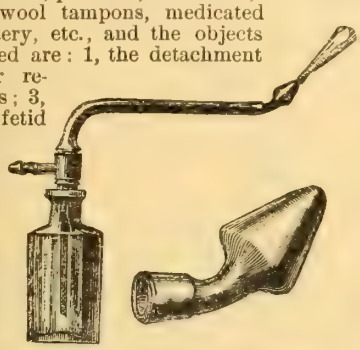

Fig. 2734.—Lefferts' Spray Producer.

Topical applications to the nasal passages and naso-pharynx should cause no unnecessary irritation of the mucous membrane, which is, as a rule, more sensitive than that of either the pharynx or the larynx.

They are to be persistently and regularly resorted to by the patient, who should be early impressed with their necessity and value. Most of the instruments devised for applying medicines to the nasal passages can be used by the patient on himself, but should not be entrusted to him exclusively.

Sprays may be both of a detergent and remedial nature, and afford a safe, complete, and easily applied method for the management of true ozæna. They may be administered from the hand-ball spray apparatus, from the steam atomizer, from the more convenient compressed air-spray machines, or from a Lefferts' spray producer (Fig. 2734).

Detergent sprays should be of a rather mildly alkaline and antiseptic character, and should always be employed

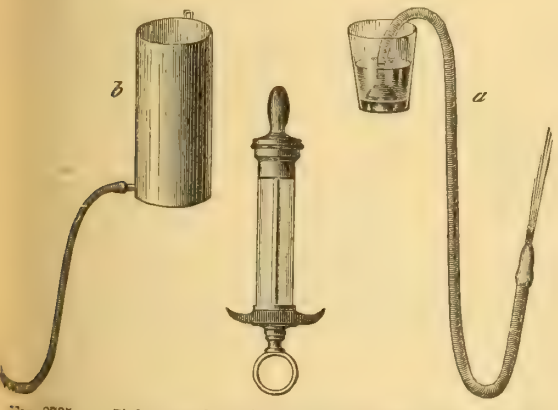

Fig. 2735.—*a*, Siphon nasal douche; *b*, Weber's nasal douche; *c*, barrel nasal syringe.

in the anterior and posterior nares before applications of medicine are made to the diseased parts.

The alkalinity of a spray facilitates the dissolving of crusts, and its antiseptic ingredients correct the toxic effects of decomposing secretions upon the nares and general health.

Among the most useful of this class is *Dobell's solution*, of which the *original formula* is herewith given, with Dobell's statement that ammonium chloride, potassium chlorate, or Condy's fluid may be used in the place of the borax.

*Dobell's Solution.**

℞. Sodii boratis..... ʒ j.
Glycerini acidi carbolici (Br. Ph. or U. S. Ph., 1870)..... f ʒ ij.
Sodii bicarbonatis..... ʒ j.
Aquæ tepidæ (90° F.)..... Oss.
M.

There are several questionable modifications of the above formula, all incorrectly passing under the name of Dobell's solution, and care should be exercised in obtaining a well-made solution.

Another detergent and antiseptic spray is:

℞. Sodii boratis,
Sodii carbonatis.....āā ʒ j.
Liq. sodæ chloratæ ..... f ʒ ss.–f ʒ iij.
Glycerini..... f ʒ vj.
Aquam.....ad f ℥ iv.
M. Sig.—To be used as a spray.

Collunarium Zinci Boratis Co. (Morgan).

℞. Zinc chloride..... gr. xx.
Boric acid..... gr. xv.

After dissolving in twelve fluidounces of distilled water the solution is to be neutralized with water of ammonia. Lastly, add two fluidounces of glycerine, and filter. It can be used as a wash or spray, pure or diluted with water.

Fig. 2736.—Method of Using the Nasal Douche. (Bosworth.)

The writer makes daily use of the following formulæ as cleansing agents in the form of spray or solution:

℞. Listerine,
Glycerini boracis.....āā f ℥ ij.
M. Sig.—To be used in the spray in the proportion of one part to seven of water.

℞. Ominico..... f ℥ jss.
Glycerini boracis..... f ℥ ijss.
M. Sig.—To be used in the spray in the proportion of one part to seven of water.

℞. Thymol..... gr. j.
Alcoholis..... f ʒ j.
Glycerini..... f ʒ ij.
Aquam.....ad f ℥ j.
M. Sig.—Use as a spray.

* See Dobell on Winter Cough, etc., 8vo, third edition, 211. London, 1875.

The infusum picis liquidæ (U. S. Ph.) constitutes a soothing and highly disinfectant preparation, used either as a spray or wash. Acidum carbolicum ♏xx., or creasotum ♏xx., to aq. calcis Oj., will be found an efficient spray or wash.

Sprays of the following medicaments, in the strength indicated to the ounce of water, are recommended either as antiseptics, detergents, astringents, or resolvents: Ammonium chloride, gr. v.–xxx.; potassium permanganate, gr. ij.–v.; potassium chlorate, gr. v.–x.; zinc sulphate, gr. j.–x.; zinc sulpho-carbolate, gr. j.–x.; zinc chloride, gr. j.–x.; sol. chlorinated soda, ♏xx.–f ʒ j.; chlorine water, ♏xx.; creasote, ♏ij.–v.; carbolic acid, ♏ij.–v.; boric acid, gr. j.–x.; sodium benzoate, gr. iij.–x.; gold chloride, gr. j.–v.; gold and sodium chloride, gr. ij.–v.; glycerite of borax, f ʒ j.–f ʒ iij.

Where a mildly astringent, alkaline, and antiseptic spray is indicated the following may be used:

℞. Acidi carbolici cryst. ..... gr. x.
Pini canadensis ext. fld. ..... f ʒ j.
Glycerini boracis ..... f ʒ iij.
M. Sig.—One part to seven of water in spray.

Vapors are occasionally beneficial and must be inhaled at a temperature of from 140°–150° F. from a cup Martindale or Bullock inhaler, or other apparatus, furnished with a suitable nasal fitting, into which water and the desired medicament have been placed. Among the most useful of the moist or steam inhalations are:

℞. Creasote ..... ♏v.–x. to water Oss.
Tr. benzoin comp. f ʒ ij.–f ʒ iij. to water Oss.

To the above may be appropriately added the vapor acidi benzoici; the vapor acidi carbolici; the vapor ammonii benzoati; the vapor ammoniæ; the vapor cubebæ; the vapor iodi; the vapor pini sylvestris; the vapor terebenæ, and the vapor thymolis, all of the London Throat Hospital Pharmacopœia.

Fig. 2737.—Post-nasal Syringe.

The patient should remain in-doors for some time after using these vapors.

The fumes of nascent ammonium chloride may be inspired through the nasal passages by the patient from a Kirkwood or other inhaler, or forced into the anterior nares from a Cohen-Lewin inhaler, and are beneficial in promoting secretion. An excellent method for the administration of nascent fumes of ammonium chloride is to place the patient in a closed room and generate the fumes from sodium chloride and sulphuric acid mixed in one saucer, and water of ammonia in another by its side.

In this manner a prolonged inhalation can be taken with little effort to the patient.

This particular process is, so far as I am aware, due to Dr. William M. Mew, U. S. Army Chemist, Washington, D. C., and has been long and successfully used by the writer.

A simple, inexpensive inhaler may be contrived by placing a small piece of sponge in a glass tube of one-fourth inch bore, and moistening it with a mixture composed as follows:

℞. Creasoti ..... f ʒ j.
Tinct. iodi ..... f ʒ vj.
Chloroformi ..... f ʒ j.
M. Sig.—Ten or more drops on sponge inhaler.

The above mixture may be inhaled through the nares from a sponge attached to an ordinary respirator, which may be worn for fifteen minutes morning and evening.

Solutions are best employed by means of the anterior (Fig. 2735) or posterior (Fig. 2737) nasal syringe, the siphon (Fig. 2735), or Weber bottle douche (Fig. 2735), or they may be snuffed from the palm of the hand or squeezed into the anterior nares from a sponge previously charged with the remedy. Some precautions are to be observed in the use of these cleansing solutions by means of the douche, as they may in rare instances cause ear trouble by passing into the Eustachian tube, and even into the cavity of the middle ear.

The principal cause of such an accident is traceable to involuntary swallowing during the use of the douche, or to douching with cold water.

In employing a Weber nasal douche the bottle is elevated (see Fig. 2736), the nozzle is inserted into the nar-

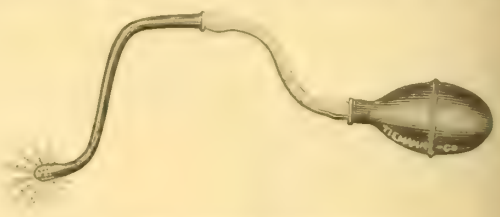

Fig. 2738.—Warner's Catarrhal Douche.

rowest nostril and pressed firmly, the mouth is held open, and the head is bent forward, when the stream will flow out of the opposite nostril if there is no obstruction.

About twelve ounces of liquid at 90° F. are to be used in each nostril, when all crusts and scabs will usually be detached and washed out.

If any crusts remain after this irrigation, they may be removed by mopping the nostrils with cotton, and, indeed, by using the forceps for their extraction.

The barrel syringe (Fig. 2735) can be used for cleansing the nares from the front, being introduced first into one and then into the other nostril, part of the liquid escaping by the mouth and part by the nostril it originally entered. If, however, the nostril is tightly compressed around the nozzle of the syringe, the mouth held open, and the head bent forward, the liquid may be made to escape through the opposite nasal passage.

The post-nasal catarrh syringe (Fig. 2737), and Warner's catarrhal douche (Fig. 2738), are both almost indispensable for cleansing the parts by way of the pharynx and posterior nares, and in using them the nozzle is inserted behind the palate, the head thrown forward, and the in-

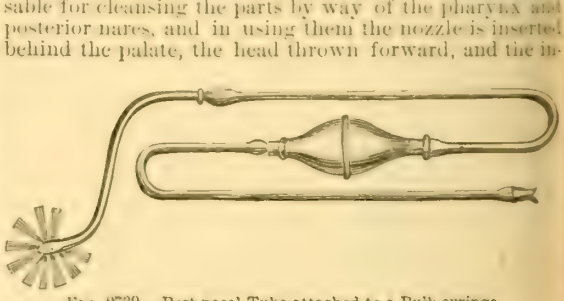

Fig. 2739.—Post-nasal Tube attached to a Bulb-syringe.

strument discharged through the nasal passages, the fluid flowing into a bowl in front of the patient.

Warner's douche (Fig. 2738) can be more readily manipulated by the patient himself than can the post-nasal syringe.

Systematic applications of solutions to the nasal passages in true ozæna, by means of the appliances described, will enable us to do much toward improving the general health of the patient and curing his local disease.

The solutions employed in the nasal douche, catarrhal douche, post-nasal or barrel syringe, etc., should have a temperature of about 90° F., and appended is a list of serviceable formulæ for such purposes, in the strength indicated to one pint of water: Carbolic acid, gr. v.–x.; sodium chloride, ʒ ss.–ʒ j.; sodium carbonate, ʒ j.–ʒ iij.; sodium borate, ʒ j.–ʒ iij.; creasote, ♏v.–x.; potassium permanganate, gr. ij.–x.; calx chlorata, ʒ ss.; liq. sodæ chloratæ, f ʒ ij.–f ʒ vj.; zinc sulphate, gr. v.–x.; zinc sulpho-carbolate, gr. v.–xv.

The addition of from one-half to one ounce of glycerine to the pint in any of the above is to be advised.

Powders.—Much has been written against the use of insufflations into the nares in treating nasal affections, but the writer is personally very partial to the employment of these preparations in suitable cases.

Powders should be used only after the diseased parts have been thoroughly cleansed and disinfected by the physician or patient, and must be evenly applied and not allowed to cake in the sinuosities of the nostrils.

Some of the powders commonly resorted to are:

℞. Iodoformi ..... 1 part.
Acidi tannici..... 1½ part.
Lycopodii ..... 2 parts.
M. Sig.—For use in the anterior or posterior (Figs. 2740 and 2741) nasal powder-blower.

℞. Acidi boracici ..... 1 part.
Resorcinæ ..... 1 part.
Lycopodii ..... 2 parts.
M.

℞. Iodol..... 1 part.
Lycopodii..... 3 parts.
M.

℞. Hydrarg. chloridi mitis..... 1 part.
Amyli ..... 2 parts.
M.

℞. Hydrarg. oxidi rubri..... 1 part.
Sacchari albi ..... 30 parts.
M.

℞. Hydrarg. ammoniati ..... 1 part.
Sacchari albi ..... 30 parts.
M.

℞. Acidi salicylici..... 1 to 3 parts.
Lycopodii ..... 10 parts.
M.

℞. Pulvis sanguinariæ ..... 1 to 2 parts.
Lycopodii ..... 2 parts.
M.

℞. Pulvis galangæ..... 1 to 2 parts.
Lycopodii..... 2 parts.
M.

℞. Iodoformi ..... 1 to 2 parts.
Lycopodii..... 2 parts.
M.

These powders should be finely ground and kept dry; they are to be applied evenly from an anterior (Fig. 2740)

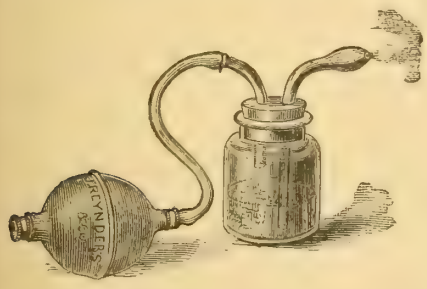

Fig. 2740.—Anterior Nasal Powder-blower. (Smith.)

or a posterior nasal insufflator (Fig. 2741), and preferably by the physician, although patients in time become quite expert in using these instruments.

The powder-blower preferred and used exclusively by the writer is one of his own design (Fig. 2742), and has the advantage of being universal and of being suitable for office work or outside practice. In the first instance this insufflator can be worked by the office compressed-air apparatus, in the latter by the hand bulbs, which run an ordinary spray. It will be noticed that the frequent and annoying accident which occurs with most insufflators, the drawing up of mucus and the caking of powder in the tube when the bulb expands, cannot take place in this instrument.

Again, the instrument is charged with a known quantity of powder, which is discharged into the nares, and not an indefinite amount from a powder bottle, as is generally the case.

This powder-blower is furnished

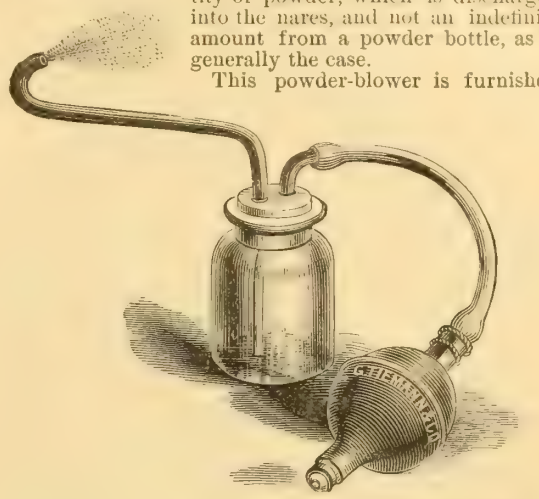

Fig. 2741.—Posterior Nasal Powder-blower. (From Robinson.)

with a scoop, and the exact amount of powder desired can readily be placed in the instrument. A trigger controls the air-blast, and the attachments for the anterior and posterior nares, ear, larynx, etc., are made to screw on, thus insuring safety.

Ointments are frequently of great value in treating this disease, and are by no means resorted to as often as they should be.

These preparations can be applied by means of a camel's-hair pencil or cotton carrier to the nasal passages, and exert a soothing disinfectant and curative influence.

Among the ointments worthy of mention are: Unguentum cadmii iodidi, unguentum hydrargyri ammoniati, unguentum hydrargyri iodidi rubri, unguentum hydrargyri nitratis, unguentum iodi, unguentum iodoformi, unguentum picis liquidæ, and unguentum sulphuris, all diluted with cosmoline, vaseline, or simple ointment to suit the particular case.

℞. Atropiæ ..... gr. ss.
Iodi..... gr. iij.
Acidi carbolici.. gr. iij.
Petrolati ..... ℥ j.
M. Sig.—Apply to nares with a brush.

℞. Iodol .....gr. xv.–xxv.
Ungt. aq. rosæ ℥ j.
M.

℞. Iodoformi ..... gr. xij.
Acidi carbolici cryst..... gr. v.
Iodi..... gr. iij.
Petrolati ..... ℥ j.
M.

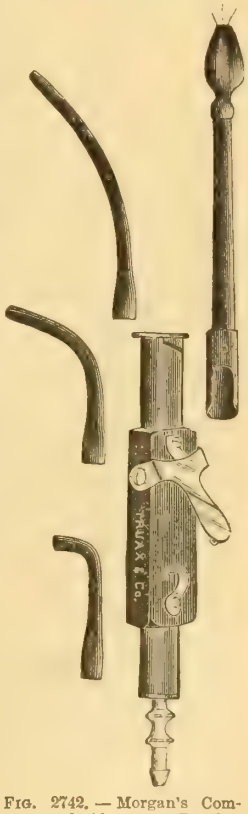

Fig. 2742. — Morgan's Compressed Air-scoop Powder-blower, showing detachable anterior and posterior nasal, ear, and laryngeal attachments. Adapted for use with rubber bulbs or with the office air-receiver.

Medicated bougies are occasionally of service in treating ozæna, the most useful being buginarium acidi carbolici,

buginarium iodoformi, buginarium thymol, etc., of the London Throat Hospital Pharmacopœia. When these bougies, which have as their basis gelato-glycerine, are introduced into the nostril they gradually dissolve, thus bringing the medicament into intimate and prolonged contact with the affected mucous membranes.

Medicated cotton-wools were introduced by Woakes, and medicines can by their use in the nares be brought into direct and constant contact with the diseased surfaces.

The gossypium acidi boracici, gossypium iodi, gossypium iodoformi, etc., are valuable formulæ.

The writer, in using these wools, generally plugs only one nostril or a portion of both nostrils at a time.

Cotton-wool tampons are recommended by Gottstein to promote a moderate but constant flow of mucus, thus preventing the drying of the mucus, which is the cause of the fetid odor.

A tampon of cotton-wool is introduced into the nasal passages by means of a screw (Fig. 2743), and permitted to remain therein a few hours every day. This treatment is said to be very beneficial in special cases, but must be persevered in for several years.

FIG. 2743.—Gottstein's Cotton-wool Tampon. A, screw armed with wadding tampon; B, the unarmed screw. (Mackenzie.)

The galvano-cautery is recommended by a few writers (B. Fränkel) as exerting a decidedly curative influence upon ozæna when used cautiously and over limited areas of the diseased Schneiderian mucous membrane and submucous tissues.

The entire nasal membrane should be cauterized during this treatment, which may consume a month or more for its completion.

The middle and inferior turbinated bodies, the roof of the nose, and, lastly, the septum should undergo cauterization. No complications worthy of mention result from such applications, and no extensive sloughing need be anticipated.

These cauterizations certainly tend to materially reduce the viscid secretion and the subsequent formation of crusts, by a reparation of the mucous membrane.

Harrison Allen appears to rely on the galvano-cautery also as a cleansing agent, and states that if a spiral-looped electrode be introduced cold into the nares and pressed against the crusts, and the electrode is heated, so firm an adhesion takes place between the heated electrode and the incrustations as to permit of their speedy and complete removal.

He states that when, after the removal of all visible crusts, the fetor persists, it is reasonable to infer that the palatal depression of the floor of the nose is filled with decomposed mucus.

The electrode, properly curved and introduced, will bring away quantities of discharge, which cannot be removed in any other way, not even by douches, etc.

Chemical caustics are, in the writer's opinion, seldom indicated in the treatment of true ozæna, although silver nitrate, chromic, acetic, and nitric acids have been recommended by a few authors.

Animal grafting by means of frog's skin and galvanism have recently been used in the treatment of ozæna.

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Ethelbert Carroll Morgan.

PÆONY (*Pivoine officinale*, Codex Med.). The Garden Pæony, *Pæonia officinalis* Linn.; Order, *Ranunculaceæ*, which is too familiar to need description, is a native of Southern Europe, and perhaps a development of *P. peregrina* Miller, of the same region. It occurs in white and red varieties, and with single, five-, or ten-petalled, or very double flowers. It is a perennial herb, with tuberous roots. The petals, seeds, and roots are official in France. The former, usually gathered from red, double flowers, and sometimes with their color heightened by acid, have a bland taste, but little odor, and no medicinal properties. They are used to give lightness and color to some sachet powders. The seeds—round, dark, and rather shiny, about as large as small peas—are said to be used in Europe to string into necklaces as charms for teething children. The roots, generally peeled, and if large sliced and dried, have a bitterish, astringent, acrid taste, with but little odor. They contain mucilage, tannin, coloring matter, and some other not very definite substances. Pæony root was formerly used as an antispasmodic, but is now obsolete.

ALLIED PLANTS.—See ACONITE.

W. P. Bolles.

PAGOSA SPRINGS. *Location and Post-office*, Pagosa Springs, Conejos County, Col.

ACCESS.—By the Denver & Rio Grande Railway to Del Norte or Alamosa; thence by conveyance.

ANALYSIS.—One pint contains (140° Fahr.):

	Grains.
Carbonate of soda	0.342
Carbonate of magnesia	0.353
Carbonate of lime	4.360
Carbonate of lithia	0.051
Chloride of sodium	2.132
Sulphate of potassa	0.519
Sulphate of soda	16.146
Silica	0.415
Organic matter	trace
Total	24.258

THERAPEUTIC PROPERTIES.—This is one of the remarkably valuable thermal springs which abound in this region. They closely resemble the Carlsbad, and are as applicable to the cure of chronic, catarrhal, and congestive disorders as are those famed waters.

These springs are situated in the southwestern part of Colorado, near the borders of New Mexico, on the banks of the San Juan River, at an altitude of seven thousand feet. To the north are the San Juan Mountains, while to the south are the plains of New Mexico. The climate and scenery are unsurpassed. *G. B. F.*

PAIN. Synonyms: Dolor, Algos, Douleur, Schmerz, etc.

Pain is a sensation felt in animal bodies, which is always of a disagreeable character, and which may vary in degree from slight uneasiness to the most intense agony. According to Erb, pain is not a sensation of a peculiar form, but one of higher degree. Every increase, then, of ordinary sensory stimulus is capable of producing pain as soon as it attains a certain intensity.

Many terms have been used to designate the various characters of pain. It is said to be acute, when sharp and violent; lancinating, when of a stabbing or darting character; lacerating, when the sensation of tearing is experienced; burning, when it resembles that produced by a burn. Other terms are similarly used, viz., smarting, stinging, griping, bearing down, etc.

Pain is a very important sign of disease, and it is always necessary to carefully ascertain its character and location. One should remember, however, that pain is often felt at a distance from the seat of the affection. Thus, in inflammation of the liver it is felt in the right shoulder, and in morbus coxæ it is usually referred to the knee-joint. Under these circumstances, it is said to be of a sympathetic character.

It nearly always occurs during an inflammation, or an ulceration, or from a sudden or gradual solution of continuity in any of the tissues of the body. It is, however, frequently experienced in a severe form when none of these conditions is present. It may be the result of a morbid sensitiveness of the sensorium without any ascertainable lesion. Pain may be produced in either of two ways: (1) By increase of the intensity of the stimulus; (2) by increase of the excitability of the sensorium (Erb). Griesinger states that the essence of pain lies in a disturbance of the organization of the nerve at some point in its course.

Patients differ very much in their susceptibility to pain. Every physician of experience will have noticed many instances illustrating this fact. Some patients are said to be of a neuralgic temperament, and feel pain intensely. Persons of different nationalities sometimes exhibit these peculiarities in a marked degree; thus, the Irishman seems to feel pain much more acutely than the Scotchman, and the Latin races are more susceptible than the Teutonic.

In locomotor ataxia pain often occurs accompanied by functional disorder of the organ which is its seat. It is then called a pain crisis. Dr. H. C. Wood thus describes this phenomenon: "A pain crisis consists, in its essential parts, of a paroxysm of pain as violent as human nature can endure, accompanied by excessive functional disorder of the part attacked, but disappearing as rapidly as it appeared, and associated with a condition of undisturbed functional activity of the affected viscus between the paroxysms."

Pain occurs more frequently and in a greater degree in those parts of the body which may be included in what Dr. Wilkes calls the outer shell. Thus extensive ulceration may occur in the stomach and intestines with very little pain. Cartilage is never the seat of pain. Lesions of the brain are rarely accompanied by sensation in that organ, but often by severe pain referred to the extremities.

We will now proceed to consider pain from a diagnostic point of view. Observation on this subject, however, should be prefaced by the assertion of Dr. Laycock, that pain, whether local or general, may be illusive as to both seat and cause. We must therefore view with some reservation these phenomena as they are exhibited in individuals.

For the purposes of diagnosis we will divide the body into four regions—the head, chest, abdomen, and extremities.

For head pain the reader is referred to the article on Headache, in the third volume of this work.

THE THORAX.—In *pneumonia* the pain is often acute and lancinating, and, according to Flint, it is most frequently confined to a circumscribed space near the nipple of the affected side. It is increased by coughing, and is also one of the causes of coughing. It is due to the pleurisy which almost always accompanies pneumonia. When the inflammation commences at the apex, or in the centre of the lung, the pain appears late in the disease. It sometimes assumes the character of lumbago. There is often hyperæsthesia of the affected side. In rare instances the pain is felt on the sound side.

Acute Pleurisy.—The pain is usually intense, sharp, cutting, or lancinating, increased by respiration, by coughing, sneezing, and by the movements of the body. It is located in the middle and lower parts of the chest, often in the subaxillary and in the epigastric regions. It frequently interferes with the function of respiration in such a way as to produce a peculiar catching sensation.

Bronchitis.—Pain is not severe. Unpleasant or painful sensations of an oppressive character are experienced behind the sternum, radiating toward the sides. A feeling of rawness is noticed in the same region. As a result of coughing pain is often felt over the short ribs and in the epigastric region.

Pleurodynia.—Pain is more or less diffused, and is increased by movements of the body as well as by those of respiration.

Intercostal Neuralgia.—A dull and persistent pain, interrupted by exacerbations of an acute, lancinating character, is characteristic of this condition. We have the three tender points of Valleix, viz., posteriorly, near the dorsal vertebræ; laterally, in one, two, or three intercostal spaces; anteriorly, in one or two intercostal spaces near the sternum, most frequently on the left side.

Pneumothorax.—The occurrence of perforation is accompanied by a sharp pain in the side, followed by the most intense dyspnœa. Occasionally there is a distinct sensation of tearing, followed by a feeling as of fluid trickling down the side. Cases occur in which these symptoms are not present in a marked degree.

Pericarditis.—Pain is acute, darting, and paroxysmal, and is increased by deep respiration and by coughing. An indefinite sense of distress in some cases takes the place of pain. Tenderness is more or less marked over the præcordial region.

Endocarditis.—Pain of a dull character is not constant and is rarely prominent. The patient may complain of a sense of distress rather than of pain. Rosenstein says it is never present unless there is pleurisy or pericarditis.

Valvular Lesions.—Pain, when present, may be felt over the heart or in the left shoulder. It may extend down the inner side of the left arm to the fingers. It may be constant and aching, or stabbing and darting. It is often paroxysmal, especially in aortic regurgitation. Numbness of the left hand and arm is sometimes experienced following the course of the ulnar nerve. The pains are generally aggravated by anything which excites the heart's action, or by distention of the stomach. They are frequently relieved by the patient leaning over the bed or chair, and thus pressing on the præcordial region.

Angina Pectoris.—The pain is sudden, intense, and of a burning, lancinating character. It arises in the cardiac region and beneath the sternum, and shoots toward both sides of the chest. It often passes down the left arm, and occasionally down the right arm. In rare cases it has extended to the neck, head, and inferior extremities. "The suffering is as sharp as anything which can be conceived in the nature of pain, including, moreover, something which is beyond the nature of pain, a sense of dying" (Latham: Disease of the Heart).

Thoracic Aneurism.—The pain is of an intense, aching, boring character, referred to the seat of the tumor. In addition, pain of an intermittent nature is often experienced, which extends along the course of the contiguous nerves.

Mediastinal Tumor.—The pain in this condition is deeply seated in the chest or back, and is not so severe as in aneurism. In most cases it is not troublesome until the tumor extends beyond the mediastinum.

Abdomen.—*Parenchymatous Hepatitis.*—In this condition pain, usually of a dull character, is felt in the hepatic region. It sometimes extends backward under the right scapula and upward to the shoulder, especially when the convex surface of the liver is involved.

Suppurative Hepatitis.—Pain is felt in the right shoulder in a small number of cases. Serious inflammation of the liver may take place, when deeply seated, without pain. The nearer the surface the greater the disturbance.

Cirrhosis.—Pain in the hepatic region is only noticed in a small number of cases. There is sometimes a feeling of weight or a dull pain in the right hypochondrium, more or less persistent or recurrent.

Cancer of the Liver.—Pain is a prominent symptom, and is felt in the right hypochondrium, darting in various directions. It is most severe when there is tension together with peritoneal inflammation. It is increased by pressure. In a few cases it is not experienced.

Biliary Calculi.—The pain is sometimes preceded by a sense of uneasiness, but more often comes on suddenly. It is of a severe, cutting, tearing character, causing the patient to shout out and to assume various positions in order, if possible, to get relief. It frequently spreads over the abdomen and up into the chest. There is often tenderness over the region of the gall-bladder, but in some cases pressure produces temporary relief.

Dyspepsia.—Pain of a hot, burning character is sometimes felt at the cardiac orifice of the stomach. It passes into the chest or up the œsophagus into the throat. A sense of fulness, sometimes amounting to pain, is often experienced after eating.

Gastritis.—Pain is experienced of a hot, burning character, greatly increased by the ingestion of food, especially if the latter is of a solid or stimulating character. Great irritability of the stomach is also experienced. There is moderate tenderness on pressure. The corrosive and irritant poisons produce the symptoms of gastritis, which vary in severity according to the nature and strength of the toxic agent.

Alkalies produce a burning sensation not so severe as that caused by acids. In the case of the narcotic irritants a little time may elapse after the taking of the poison before the pain is experienced.

Gastralgia.—This is a neuralgic affection of the stomach, consisting of pain more or less severe, accompanied by spasm. We meet with it, according to Flint, in two forms, the acute and chronic. In the acute form the pain is of a griping and tearing character, and sometimes is so severe as to produce fainting. Romberg describes it as if "claws were clutching the pit of the stomach." A sense of constriction is frequently experienced, and occasionally vomiting.

In the chronic form the pain may be continuous, with exacerbations, or it may recur at intervals. It varies in intensity, and is of a burning, lancinating, or gnawing character (Flint). It originates in the region of the stomach, and shoots in various directions. It may be provoked by the ingestion of food, but, as a general rule, it is relieved by eating.

Cancer of the Stomach.—Pain is more or less prominent. It may be lancinating, or of a gnawing character, especially if there is secondary ulceration. It is absent in eight per cent. of the recorded cases.

Gastric Ulcer.—Tenderness on pressure is almost always present. A burning, gnawing pain is produced by the ingestion of food, especially when the latter is of a hot, stimulating character. The pain continues until the food is either rejected or passes through the stomach. It is affected by the position of the body. Sometimes lying down will relieve it, while in other cases it is made worse by the recumbent posture, depending, no doubt, on the situation of the ulcer (Flint). It is often absent for days. It may be excited by deep inspiration, especially if localized peritonitis is present.

Intestinal Colic.—Pain is felt in the neighborhood of the umbilicus, and is of a very severe character. It causes the patient to bend forward and press the abdomen in order to obtain relief. It lasts for a few moments, and then, to a greater or less extent, disappears, only to return after a short interval.

Enteralgia.—In this affection the pain is not of that griping character which is experienced in colic, but is of a tearing and cutting nature. It is felt first in the right iliac and umbilical regions. It occurs with intermissions and remissions, and is rather relieved than aggravated by pressure.

Acute Enteritis.—The pain, often felt near the umbilicus, is not severe, but rather of a dull, aching character, marked by exacerbations. There is slight tenderness on pressure.

Phlegmonous Enteritis (Cullen).—In this affection the pain resembles that of peritonitis, but is not so severe. It is increased by movements of the body.

Duodenal Ulcer.—Pain occurs in paroxysms similar to that of gastralgia. It is felt principally in the right hypochondrium, some time after the ingestion of food.

Intussusception.—This condition is accompanied at first by paroxysmal pains similar to colic, emanating from a certain locality which afterward becomes tender on pressure.

Strangulated Hernia.—The descent is accompanied by severe pains in the region of the umbilicus, which may closely simulate those of colic.

Functional Obstruction.—Painful peristaltic movements occurring in paroxysms are strongly diagnostic of this condition.

Sporadic Cholera.—Colicky pains of a severe character precede and accompany the passages from the bowels.

In *epidemic cholera* the dejections are not accompanied by pain, but rather by a feeling of relief.

Lead Colic.—The pain may be slight or severe. In the latter form it is sharp and lancinating, and spreads over the abdomen. It may be confined to the hypogastrium or epigastrium. In severe attacks it is relieved by pressure. It is often marked by tenesmus.

Acute Diffuse Peritonitis.—The pain may at first be localized, and afterward become general. It is of a burning, lancinating character, increased by deep inspiration, coughing, sneezing, or by movements of the body. It frequently occurs in exacerbations, and is generally severe, but it may be slight or wanting.

Abnormal conditions of the uterus and appendages, as hypertrophy, displacement, endocervicitis, ovaritis, salpingitis, etc., are marked by pain in the seat of disease. These affections, however, are frequently accompanied by sympathetic pains in other parts of the body—in the back, breast, and extremities.

Renal Colic.—The pain, at first of a pricking character, is felt in the lumbar region. It quickly becomes very severe, often most excruciating, and passes down along the ureter to the bladder. It is also felt in the penis and testicles. It may pass across the abdomen, and upward to the chest.

The Back.—*Aneurism of the Descending Thoracic Aorta.*—The pain is of an aching, burning character, corresponding *in situ* to the position of the tumor. Radiating neuralgic pains are also frequently present.

Aneurism of the Abdominal Aorta.—In this condition pain of an intense and paroxysmal nature is felt in the abdomen when the tumor extends forward, and in the back when it arises from the posterior portion of the aorta.

Hæmorrhage into the substance of the spinal cord is marked by sudden paralysis without loss of consciousness, and by localized pain.

Spinal Meningitis.—Pain in the spine, of a deep-seated and boring character, is felt radiating to the extremities, and is made worse by moving the limbs. It is not much increased by pressure.

Cerebro-spinal Meningitis.—The pain is experienced in the cervical, dorsal, and abdominal regions, depending on which part is inflamed. It is made worse by movements of the body.

Pott's Disease of the Spine.—The pain at first is often severe, and is increased by active exercise. It sometimes shoots forwards over the abdomen and into the extremities.

Myelitis is marked by pain in the back, and a girdle sensation around the abdomen and into the extremities.

Locomotor Ataxia.—Pains are of a fulgurating character, shooting down into the extremities, and there are girdle pains around the abdomen.

Spinal Irritation.—Tenderness and pain on pressure are felt over the spine. Pressure also causes pains radiating to the trunk and limbs.

Lumbago.—A dull pain, often severe and aggravated by movements of the body, is experienced in the small of the back. It is accompanied by a feeling of stiffness and inability to assume the erect posture.

Dorsodynia.—Pain in the dorsal region, increased by movement of the scapula. In this and the preceding affection, uniform, firm pressure over the affected muscle will give relief.

In acute and chronic inflammation of the kidneys, a dull pain in the back is often experienced.

Dull pains in the back are often the result of alcoholic or venereal indulgence.

The Extremities.—Here we shall refer only to pains which are of obscure origin. It is much less difficult to differentiate gross anatomical lesions in the limbs than in the trunk, and consequently the character of the pains is not of so much diagnostic importance.

Dr. H. C. Wood, in his recent work, has given the following as the causes of persistent pains in the extremities: 1, Gout or rheumatism; 2, neuritis; 3, chronic metallic poisoning; 4, diseases of the spinal cord; 5, neuralgic and malarial cachexiæ.

In gout or rheumatism, pains, when not resulting from gross anatomical lesions, are often of an obscure character. They are dull and aching, and occur around the joints and in the muscles. There may or may not be tenderness on pressure. Pains of a rheumatic nature are often mistaken for those resulting from sprains.

Neuritis.—Pain exists in the affected nerve and the parts to which it is distributed. Gowers describes it as of an intense, burning, boring, rarely of a darting, character. It is worse at night, and is made worse by such movements as increase the tension of the affected nerve-trunk. In severe cases the whole limb may be affected, but in the milder forms the pain is confined to the course of the nerve itself.

In chronic metallic poisoning pain is not a prominent symptom, so far as the limbs are concerned. It may be neuralgic in character, or it may be dull and more of the nature of rheumatism. In chronic lead-poisoning severe pains are often experienced in certain joints and the neighboring muscles. They are sometimes attended by cramps, and do not follow the course of the nerves.

Of the diseases of the spinal cord, posterior sclerosis is the most frequently accompanied by pain in the limbs. The peculiar character of these has been already described. Generalized pains in the limbs may occur in diffuse and transverse myelitis, compression followed by myelitis, also in acute and chronic spinal meningitis. Caries of the vertebræ, perineuritis, and pressure from tumors on the nerve trunks will produce pain in the limbs.

Some idea of the causes of limb pains may be obtained by noticing whether they are unilateral or bilateral. In diseases of the cord the pains are usually bilateral, as is also the case in those produced by toxic agents in the blood. Unilateral pains, on the other hand, are usually the result of some inflammatory lesion in the course of the nerve. It is quite possible that this lesion may be primarily produced by such toxic agents as syphilis, tuberculosis, etc.

The Neuralgias.—Neuralgic pain may be entirely paroxysmal, or it may be continuous, accompanied by exacerbations. The continuous pain is dull in character, but the exacerbations may be acute and lancinating.

Valleix's painful points are diagnostic of neuralgia. They occur as follows: 1, Where the nerve passes out from the skull or spinal column; 2, over branches which, passing outward, penetrate muscles; 3, at the termination of branches on the surface; 4, over trunks near the surface.

In brachial neuralgia the pain is of a continuous, dull, boring, burning character (Erb). It may also be violent, tearing, and lancinating, shooting down to the hand. It may present exacerbations and remissions.

In sciatica the pain may be preceded by dull, painful sensations, which gradually increase in intensity until a paroxysm occurs. It follows the course of the nerve, shooting backward and forward from place to place.

The painful points are: (1) Where the nerve passes out through the sciatic foramen; (2) the lower border of the gluteus; (3) over the head of the fibula; 4, behind the outer ankle; (5) behind the inner malleolus.

Neuralgia of the joints is characterized by a dragging, tearing, stabbing pain, which shoots in various directions. As a rule, sleep is not disturbed by it. The opposite is the case in inflammation. It also occurs in spasms, which are worse at certain times of the day.

Treatment.—The treatment of pain is often a very important part of the management of disease. When severe it requires immediate attention. The administration of hypodermic injections of morphia, or of the same drug by the mouth, is the remedy most frequently used. Other anodynes, such as ether and chloroform, may be given in addition. When the patient cannot take morphia, as is occasionally the case, hyoscyamus, belladonna, and Indian hemp may be resorted to. Local applications of heat, mustard, and turpentine often give relief. The principal object of the physician, however, should be to find out the cause, and, if possible, to remove it.

James E. Graham.

PANCREAS, INJURIES AND DISEASES OF THE.

Of all abdominal organs the pancreas has been least frequently subjected to surgical treatment. The anatomical location of the organ, and the obscurity of its affections, furnish a sufficiently satisfactory explanation of this statement. Situated high up in the abdominal cavity, and hidden behind such important organs as the stomach, omentum, and transverse colon, it is the least accessible of all abdominal organs, and on this account its affections, wrapped in obscurity, have for the most part constituted objects for empirical medication. The relation of this gland to surrounding organs, and its great distance from the anterior wall of the abdomen, the only point of approach, necessarily offer serious obstacles to diagnosis and direct treatment. In a diagnostic point of view, I may also refer to another great difficulty—our want of positive knowledge concerning the physiological functions performed by this gland in the process of digestion. As the symptomatology of all affections of the pancreas is always obscure, and a probable diagnosis can be made only in cases in which the gland has become considerably enlarged by disease, it is apparent that our present clinical knowledge is limited to diseases which increase the size of the organ to such an extent that their existence may be determined by palpation. Primary malignant disease of the pancreas, when it has advanced to such an extent that its presence can be diagnosticated with certainty by physical signs, will have invaded the adjacent tissues to such a degree as to preclude the advisability of an operation; consequently the efforts of the surgeon, for the present at least, must be directed almost exclusively toward the recognition and treatment of benign affections of this gland.

As the internal treatment of diseases of the pancreas always has been, and probably always will be, an ungratifying task to physicians, the following article has been written with special reference to laying the foundations for a rational method of treatment of some of the injuries and diseases of the pancreas by direct surgical measures, as many of its affections legitimately come within the domain of modern surgery; while other more obscure diseases can be treated by internal medication,

with any hope of success, only after the physiology of the pancreas, the etiology and pathology of its diseases, shall have been better understood as the result of future research.

The literature of the surgery of the pancreas is exceedingly scanty, and loosely scattered through the medical journals and text-books, as no previous attempt has been made to arrange the material in a systematic form for ready reference. Our present knowledge of the surgical treatment of diseases of the pancreas is limited to a few operations, performed for the cure of retention-cysts, by excision or the formation of an external pancreatic fistula. The clinical material which I have collected, and more particularly the description of pathological conditions found within and around the pancreas at post-mortem examinations, will be utilized for the purpose of pointing out new indications for operative interference, by such methods as will suggest themselves from the results obtained by experiments upon animals.

Topographical Anatomy.—For a correct interpretation of the signs and symptoms of injuries and diseases of the pancreas, and for an accurate understanding of the relations of this organ to surrounding parts in their surgical treatment, it becomes necessary to allude briefly to the topographical anatomy of the pancreas. The pancreas is a tongue-shaped gland, placed transversely in the abdomen at a point opposite the first lumbar vertebra, behind the stomach, reaching from the hilus of the spleen to the concavity of the duodenum. Its right end, termed the head, is embraced by the curvature of the duodenum, while its left, or caudal extremity, is in contact with the spleen. After opening the abdominal cavity in the cadaver, it can be distinctly felt, as a firm body, through the walls of the stomach. The organ is made accessible and exposed to sight by cutting the ligamentum gastro-colicum transversely, and by pushing the stomach upward and the transverse colon downward. In the saccus epiploicus, which has now been opened, the gland is seen in front of the large vessels. It presents three surfaces for examination. The anterior surface, somewhat concave, is in contact with the stomach throughout its entire extent, but separated from it by a covering from the omental bursa, which renders the surface smooth and well adapted for the free movement of the stomach. The posterior surface is separated from the spine by the vena cava, aorta, the superior mesenteric artery and vein, the pillars of the diaphragm, and, toward the liver, the vena porta, as well as numerous lymphatic vessels and glands, all of which are firmly connected with this surface and with the spine by connective tissue. To the left of the vertebral column it is attached in the same manner to the left suprarenal capsule, kidney, and renal vessels. The superior mesenteric artery and vein are embraced by the substance of the gland, so as sometimes to be enclosed in a complete canal. The inferior surface is narrow and directed toward the transverse colon; it rests at one end on the junction of the duodenum and jejunum, at the other end on the extremity of the transverse colon. The intervening middle portion of the inferior surface has a special peritoneal covering derived from the lower layer of the mesocolon. Along the posterior surface and upper border of the gland are placed the splenic artery and vein, both pursuing a tortuous course from right to left. The cœliac axis is above the pancreas. The common bile-duct is in close relation to the head of the gland, passing down along its posterior surface, and is generally received into a groove or canal in its substance.

The common pancreatic duct, or canal of Wirsung, is widest near its entrance into the duodenum, where it is from one-twelfth to one-ninth of an inch in diameter. Before its termination it unites with the common bile-duct in the wall of the intestine, at the junction of the second and third portions of the duodenum, between three and four inches below the pyloric orifice of the stomach. The lower extremity of the head, where it curves behind the mesenteric artery and vein, is sometimes marked off from the rest, and is then called the *lesser pancreas*, having a special duct which joins the common duct in the substance of the head of the pancreas.

The pancreas receives its blood-supply from the superior and inferior pancreatico-duodenal branches of the hepatic and superior mesenteric arteries. The venous return takes place through the splenic and superior mesenteric veins. The nerves are derived from the solar plexus.

Accessory Pancreas.—The pancreas, like many other glandular organs, sometimes presents rudimentary duplicities, and it is necessary to call attention to this fact for the purpose of considering the possibility of the origin of a pancreatic cyst from one of these appendages. Rokitansky[1] mentions, as an exceedingly rare occurrence, duplicity of the pancreas and excessive development of the accessory appendages. A frequent variety is presented by the head of the gland—the pancreas minus—the duct of which usually terminates in the common duct; but sometimes, as was first ascertained by Winslow, it takes an independent course and empties into the duodenum from one to one and a half inch below the opening of the common duct. More recently, Hyrtl has called attention to an accessory pancreas, consisting of a few isolated acini of the gland behind the superior mesenteric artery and vein. Klob has described an accessory pancreas, distant and distinct from the normal organ, which was found between the muscular layers of the stomach, about the middle of the great curvature. On another occasion he found a similar organ in the posterior wall of the jejunum, near its upper termination. In both instances the true glandular structure of these bodies was confirmed by microscopical examinations.

Zenker met with six instances of supernumerary pancreas. The accessory organ was invariably in the walls of the intestine, three times in the highest convolution of the jejunum, twice near the duodenum, and in the last case in the upper part of this portion of the intestinal tract. In size the glands varied from that of a lentil to that of a silver dollar. They were situated between the intestinal tunics, and presented a prominence on the serous surface. Klob found no excretory duct in his specimen. Zenker detected the terminal end upon the mucous surface of the intestinal canal, in the shape of a slightly raised papilla which could be seen with the naked eye, or by means of a magnifying-glass. The presence of pancreatic juice in the glands was also determined. In all instances the gland proper was found in its normal location and of natural size. All the subjects were adults. Like other accessory organs the supernumerary pancreatic glands owe their origin to embryonal deposits of gland tissue. Although, as yet, no instance has been observed of cystic formation from an accessory pancreas, there is no reason why such an occurrence should not take place, for the same reasons and in the same manner as has been observed in cases of cysts from supernumerary thyroid glands.

Comparative Anatomy of the Pancreas.—A few words on the comparative anatomy of the pancreas are necessary in order to compare the results obtained by certain experiments with similar conditions when observed in the human subject as the result of traumatism or pathological changes. In some of the higher invertebrates certain organs connected with the alimentary canal have received the name of pancreas; but this name has been applied to them rather from their position and inferred function than from any certain evidence of their use, or from their anatomical structure.[2] If they exist they consist of simple cæcal appendages attached to the upper part of the intestine.

In the osseous fishes certain cæca, or blind tubes, may be seen at the commencement of the intestinal canal, close to the pylorus, which from their position have received the name of pyloric appendages, and have been regarded by most anatomists as the analogue of the pancreas in higher animals. In reptiles we find a nearer approach to the structure of the pancreas of higher animals, both in form and structure. In the frog the pancreas is shaped not unlike that of the human subject, but its broad end is in the opposite direction. It is in close approximation with the duodenum in its whole length. A proper duct cannot be found; probably small

ducts from different parts of the gland open into the biliary duct as it passes through the gland. The pancreas of birds is proportionately larger than in any other animal. The gland has always more than one, usually two or three ducts which open by separate orifices, and often at some considerable distance from one another.

The chief differences between the pancreas in other mammalia and the organ in man relate merely to its color, its consistence, its degree of lobulation, its form, its volume, its union into a single mass, or its separation into two distinct parts, and, lastly, its position and its relations with different portions of the peritoneum.

Its form is generally more or less that of a narrow band, divisible into two portions—one, the duodenal, following the curvature of the duodenum, and placed vertically or obliquely; the other, the gastro-splenic, extending transversely, in relation to the first portion, from the duodenum to the spleen, against which it rests; the latter is always developed, the former is often defective or absent, and must be considered merely as an accessory portion.

In the carnivora the pancreas is always large in proportion to the size of the animal. In the ox, from the distinctness of the two portions, the organ has a bilobar appearance. In the horse, from the gastro-splenic portion being doubled, it has a trilobar form. In the rodents the organ is spread out in an arborescent manner, in an extensive mesentery that allows free movement to the long duodenum, and extends to the left in a sort of omentum which underlies the stomach. In the rabbit the duct enters the intestine nine inches or a foot from the pylorus. In the mammalia, as in man, there is, as a rule, but one pancreatic duct, which usually enters the intestine near the pylorus, although sometimes a great way removed from it. There are, however, considerable variations in the mode of insertion. In the lion two pancreatic ducts join the common bile-duct separately, one near the other. In the dog I have made the observation that the ducts from both portions of the pancreas unite near the duodenum or within its wall, and that the orifice of the common pancreatic duct is usually located about an inch or two below the opening of the bile-duct.

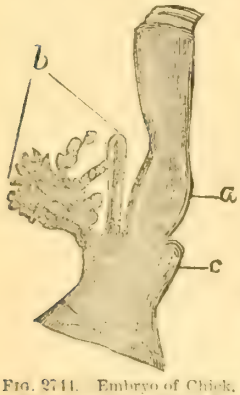

Fig. 2744. Embryo of Chick, Four Days Old. (From Remak.) *a*, Stomach; *b*, liver and bile-ducts; *c*, pancreas.

If an accessory duct exists, it usually opens into the intestine at a point in common with the bile-duct.

Bérard and Colin[3] have shown that the pancreas is not connected with the duodenum in young dogs. It consists originally of two parts, of which one lies parallel to the duodenum (caudex inferior), and the other perpendicular to it (caudex superior). These two portions join later to form a mass which becomes adherent to the duodenum. Each portion has its own duct, and the two afterward unite to enter the intestine about two and a half centimetres (one inch) below the opening of the bile-duct. Sometimes there is a second duct arising from either portion, or more rarely from both, which enters the duodenum by the side of the bile-duct.

The pancreas of the pig has usually only one duct, but when two exist the second smaller duct communicates with the principal duct, which opens into the common bile-duct.

The irregular distribution and insertion of the pancreatic duct in mammalia, and the frequency with which a second and third duct are found, are important to remember in connection with experiments on the pancreas, for intercepting the secretion by ligation of the duct; for it is exceedingly difficult, if not impossible, to ascertain the existence or absence of the small accessory ducts; and on this account it would be impossible to prove that all of the outlets of the gland had been intercepted, even if the duct of more than one gland had been found and ligated.

Development of the Pancreas.—Remak has studied the development of the pancreas in the young chick.[4] He found that the matrix could be seen somewhat later than that of the liver—about sixty-five hours after incubation had commenced. It consists, primarily, as a bulging of the hypoblast of the posterior wall of the intestinal tube, covered by a thickened prolongation of the connective-tissue layer of the bowel (Fig. 2744).

The embryonal pancreas shows in the beginning a cavity which is in communication with the open lumen of the bowel. The changes which take place in the embryonal pancreas during the first five days can be readily observed and are easily understood.

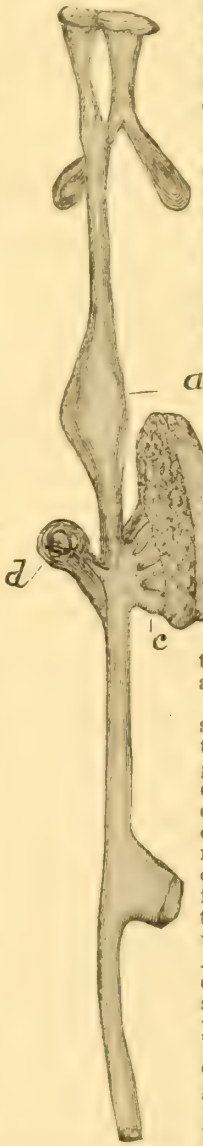

Fig. 2745.—Embryo of Chick, Five Days Old. *a*, Stomach; *b*, liver and bile-duct; *c*, gall-bladder; *d*, pancreas.

From the thick wall of the hypoblast numerous small, solid lobules spring, while the hollow space in communication with the bowel assumes more and more the shape of a canal. The connective-tissue layer does not increase in size in the same degree, and presents no lobular projections upon its surface. On this account the new organ has assumed a pyriform shape externally; on the other hand, the glandular portion in the connective-tissue layer takes on a branched structure (Fig. 2745).

The hypoblastic layer is the basis of the parenchyma. Composed of cells, the connective-tissue layer serves as a basis for the vascular constituents of the gland. The embryonal connective tissue disappears during the development of the gland in proportion as the cellular portion increases, until, finally, only enough connective tissue is left to serve as a nidus for the vessels and as a membrana propria for the acini.

The pancreas is not developed by symmetrical folding of both walls of the intestinal canal, but each wall grows by proliferation in different degrees to form the pancreas. The excavation in the rudimentary gland does not exist at first, but the original and essential structures are the cellular parenchyma of the gland from the epithelial lining of the intestine, and the vessel and nerve enveloping layer of connective tissue. As the pancreas in birds has two ducts, the question arose how the second duct is formed. The most plausible explanation was afforded by the assumption that the primary duct divides itself into two in a longitudinal direction. Remak, in 1846, found another explanation in examining two geese, between three and four weeks old. He found two ducts at a short distance from each other, in connection with the wall of the intestine. A closer examination showed, however, that only one of the ducts, the upper, was in communication with the lumen of the intestine; the other presented a blind pouch adherent to the wall of the gut. From this it may be concluded that the second duct springs from the first, and, at a later period, a new communication with the bowel is established at a point corresponding to its cæcal extremity.

Remak has since observed the same condition in the larvæ of frogs (Fig. 2746). It appears, then, established

that the first and primary duct of the pancreas is found in the rudimentary organ, and is from the beginning in communication with the bowel; while any additional ducts, whether normal or anomalous, originate in the substance of the gland and only secondarily are brought into communication with the bowel by a process of atrophy and absorption between the cæcal extremity of the duct and the intestinal wall. The existence of anomalous ducts communicating with one of the principal ducts and with the intestine can be explained in a similar manner. Thus, in dogs it is not uncommon to find a small duct, in the gastro-splenic half of the gland, connecting the intestine, at a point where the common bile-duct opens into it, with the common duct, as illustrated by specimen No. 28 in my series of experiments on the pancreas.

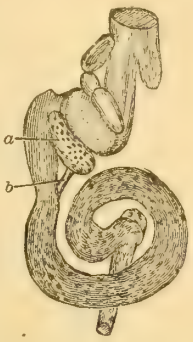

FIG. 2746.—Larva of Frog. (From Remak.) *a*, Pancreas; *b*, pancreatic duct.

It is apparent that in cases of this kind obliteration of the common duct on the distal side of the anomalous or accessory duct would not interfere with the normal evacuation of the secretion into the intestinal canal. The occurrence of an accessory pancreas can only be explained by the assumption that, during the growth of the rudimentary pancreas, certain portions of the secreting structure become isolated by constriction and displacement, and that such portions of the gland are brought into communication with the intestinal canal by the development of an accessory duct.

PHYSIOLOGY OF THE PANCREAS.—A brief consideration of the most important functions of the pancreas becomes necessary in connection with our subject, as it will serve to furnish an interpretation of some of the symptoms observed in such affections of the pancreas as interfere with the normal secretion or outflow of the pancreatic juice.

Claude Bernard, in 1848, discovered the most important function of the pancreatic juice, by observing that it exerted an emulsifying effect upon all kinds of fat. He found that, by mixing fresh pancreatic juice with oil, lard, butter, or tallow, and keeping the mixture at a temperature of 35° to 40° C., an emulsion is formed almost immediately.[6] Saliva, gastric juice bile, and blood-serum do not produce this effect. The emulsifying process takes place through the division of the fat into minute globules by the pancreatic juice, without its being converted into a new chemical compound. The organic principle in the juice which possesses this property is very easily decomposed and precipitated by heat. Bile, with pancreatic juice, dissolves neutral as well as acid fats. Bernard ligated both pancreatic ducts in dogs, and the single duct in rabbits, and fed the animals on fat. The fat was found unchanged in the intestinal canal, and the lacteals were empty. Fatty diarrhœa has been observed in a number of cases in which the pancreas was the seat of extensive lesions, and the presence of this symptom should always lead the physician to make special search for additional symptoms confirming the suspicion of the existence of disease of the pancreas.

There is no dispute among physiologists in regard to the action of pancreatic juice in transforming starch into sugar. This function was first observed by Valentin, in 1884, who experimented with an artificial fluid made by infusing pieces of pancreas in water. Bouchardat and Sankras first observed this property in the normal pancreatic secretion. The property of converting starch into sugar is possessed also by the saliva and intestinal juice; it therefore becomes an important question to determine the effect of an imperfect pancreatic secretion in cases in which there is imperfect digestion of starchy food. It seems that cane-sugar is transformed into glucose almost exclusively by the action of the pancreatic juice. This fact has received confirmation in the case of intestinal fistula observed by Busch. The fistula was located in the lower portion of the small intestine. When cane-sugar was introduced in quantity into the empty stomach, the fluid which escaped from the upper end of the intestine contained a small quantity of glucose, but never any cane-sugar. Cane-sugar introduced into the fistula, so that it would pass along only the lower end of the bowel, was not converted into glucose, but a large portion of it was found in the fæces as cane-sugar. In cases of suspected organic lesions of the pancreas it would, therefore, appear advisable to resort to feeding with cane-sugar, followed by an examination of the stools for undigested cane-sugar, as a diagnostic measure. The presence of cane-sugar in the stools would indicate that little or no pancreatic juice is secreted.

The last function of the pancreas consists in converting, with the aid of the bile and intestinal juice, the albuminoids, such as gluten, fibrin, albumen, casein, and musculin, into albuminose or peptones. This latter effect of the pancreas has been doubted by a number of German physiologists, but the fact seems to be demonstrated by experiment, as well as by the circumstance that the pancreas is larger in carnivorous than in herbivorous animals.

Schiff has found that the physiological function of the pancreas is at its maximum about nine hours after the ingestion of food, and at its minimum about four hours later. During the period of greatest activity of the gland the vessels become more turgid, and can be seen, with the aid of a lens, between and upon the lobules, while during a state of rest they are seen only between the lobules. During digestion the gland presents a pale-red color, while during rest it appears grayish-white.

The influence of the nerve-centres upon the pancreas has been made a subject of careful study by Schiff.[6] Section of both pneumogastric nerves has no effect upon the circulation or secretion of the pancreas. Animals subjected to this experiment readily digested dextrine or peptones introduced into the stomach; but when ordinary food was given no secretion took place, as stomach digestion was suspended. Total destruction of the three semilunar ganglia of the sympathetic arrests completely the secretory functions of the pancreas, even if the most favorable conditions are established by the introduction of food or injection of the products of digestion into the stomach. Wounding of these ganglia, short of total destruction, does not produce the same effect. Injury of the spinal cord, on a level with the eighth, ninth, or tenth rib, does not interfere in the least with stomach digestion, but promptly arrests all secretion from the pancreas, which cannot be excited by food nor by the presence of dextrine in the stomach. Heidenhain has ascertained that stimulation of the medulla oblongata increases the flow of pancreatic juice as well as its active constituents. These experiments show that the reflex action of the stomach upon the pancreas is not transmitted through the sympathetic, but through the spinal cord. That the essential active principle of the pancreatic juice is necessary for digestion, has been shown by Corvisart, who found that in dogs the pancreatic juice contained, nine and a half hours after a meal, no ferment which was capable of dissolving albuminous substances. If, however, the animal was made to fast for a longer time than this, the ferment was again produced in some unknown manner. Pancreatic digestion becomes apparent six or seven hours after a meal, the time being somewhat dependent upon the duration of digestion.

The present views concerning the action of the pancreatic juice in the process of digestion may be summarized as follows:

1. Starch is converted by a diastatic ferment into dextrine and sugar, a continuation of the action of the saliva in the intestine.

2. Melted and fluid fats are emulsified by it (a property which has been assigned in a less degree to bile); at the same time, glycerine and fatty acids are formed during the process. The emulsifying process is aided by the fatty acids and alkaline salts, which effect saponification (Brücke, Gad, Quincke).

3. Albuminoid substances and glue-containing tissues, when mixed with an alkaline solution, are dissolved and

converted into peptones independently of stomach digestion (Corvisart). A portion of the peptones undergoes still further changes, as in the case of glue, there may appear tyrosin, glycin, and ammonium.

Fresh pancreatic juice obtained from the duct of Wirsung is a clear, viscid, alkaline, highly putrescible fluid, of a specific gravity of 1.030, which solidifies completely on boiling. Pancreatic juice contains: 1, Albumen; 2, a number of ferments; 3, salts, especially of soda; 4, water; sometimes traces of self-digestion of the gland can be found, especially leucin.[1]

The pancreas secretes continually in herbivorous animals; in carnivorous, only during digestion (Heidenhain). The ferments are always present in the gland, trypsin only in a state of preparation, a so-called zymogen, which, on division, yields trypsin; this division takes place on exposure of the gland to air, by the action of oxygen, of very dilute alkalies, acids, alcohol, etc. During secretion the cells of the lobules are enlarged, while the latter become swollen; at the same time the vessels are considerably dilated. The exact quantity of pancreatic juice secreted in man and most animals is unknown. From a practical point of view it is important to allude to the effect of the pancreatic juice upon the skin, which it macerates, so that when this fluid remains in contact with the skin for any length of time it becomes irritated and presents a raw, eczematous surface. It also appears that the same effect is not produced when it is brought in contact with the peritoneum, because in this locality fresh pancreatic juice is removed rapidly by absorption. A positive diagnosis of disease of the pancreas will become possible only when more attention shall be bestowed upon the symptoms arising from defective digestion, the result of a defective or faulty function of the pancreas—a pancreatic indigestion. Long-continued indigestion of fatty or starchy food should be considered a sufficient indication for instituting a most careful search for pancreatic disease, by ascertaining the effect upon digestion of particular articles of diet, and by examining with care the discharges from the bowels.

From a careful and critical examination of the results obtained by experiments upon animals, and from a study of the literature on diseases and injuries of the pancreas, the author[2] has come to the following conclusions:

1. Restoration of the continuity of the pancreatic duct does not take place after complete section of the pancreas.

2. Complete extirpation of the pancreas is invariably followed by death, produced either by the traumatism or by gangrene of the duodenum.

3. Partial excision of the pancreas, for injury or disease, is a feasible and justifiable surgical procedure.

4. Complete obstruction of the pancreatic duct, uncomplicated by pathological conditions of the parenchyma of the organ, never results in the formation of a cyst.

5. In simple obstruction of the pancreatic duct the pancreatic juice is removed by absorption.

6. Gradual atrophy of the pancreas from nutritive or degenerative changes of the secreting structure is not incompatible with health.

7. Physiological detachment of any portion of the pancreas is invariably followed by progressive degeneration and atrophy of the glandular tissue.

8. Extravasation of fresh normal pancreatic juice into the peritoneal cavity does not produce peritonitis, but is promptly removed by absorption.

9. Crushed or lacerated pancreatic tissue is removed by absorption, provided the site of operation remains aseptic.

10. Complete division of the pancreas by elastic constriction is never followed by restoration of interrupted anatomical continuities.

11. Limited detachment of the mesentery from the duodenum, as required in operations upon the pancreas, is not followed by gangrene of the bowel.

12. In all operations upon the head of the pancreas, the physiological connection of the peripheral portion of the gland should be maintained by preserving the integrity of the main pancreatic duct.

13. Partial excision of the splenic portion of the pancreas is indicated, in all cases of circumscribed abscess and malignant tumors, whenever the pathological product can be removed completely without danger of compromising pancreatic digestion or of inflicting additional injury upon important adjacent organs.

14. Ligation of the pancreas at the point or points of section should precede extirpation as a prophylactic measure against troublesome hæmorrhage and extravasation of pancreatic juice into the peritoneal cavity.

15. The formation of an external pancreatic fistula by abdominal section is indicated in the treatment of cysts, abscesses, gangrene, and hæmorrhage of the pancreas due to local causes.

16. Abdominal section and lumbar drainage are indicated in cases of abscess or gangrene of the pancreas, in which it is found impossible to establish an anterior abdominal fistula.

17. Through drainage is indicated in cases of abscess and gangrene of the pancreas, with diffuse burrowing of pus in the retro-peritoneal space.

18. Removal of an impacted pancreatic calculus in the duodenal extremity of the duct of Wirsung, by taxis or incision and extraction, should be practised in all cases in which the common bile-duct is compressed or obstructed by the calculus, and death is threatened by cholæmia.

19. In such cases the principal source of danger, extravasation of bile into the peritoneal cavity, should be avoided by preliminary aspiration of the dilated bile-ducts, accurate closure of the visceral wound with fine silk sutures, and absolute physiological rest of the organs of digestion during the time required for the healing of the visceral wound.

Wounds of the Pancreas.—Of all abdominal organs the pancreas is most exempt from injury, by either direct or indirect violence, a circumstance which is entirely due to its remote location, and the ample protection furnished by the vertebral column and the bony walls of the chest. The anatomical relations of the pancreas to numerous and important organs are such that when this organ is injured the same violence which has produced the injury has also wounded an adjacent, and perhaps more important, viscus. The frequency with which such grave complications attend wounds of the pancreas, and the profuse hæmorrhage which usually accompanies such injuries, are elements of danger which impart to wounds of the pancreas more than an ordinary degree of gravity.

1. *Contusion.*—Case 1. Cooper[3] reports the case of a man, aged thirty-three, run over by a light cart moving with great speed. No marks of external injury were visible, but the lower left ribs were fractured, and the pancreas was literally smashed and embedded in semi-coagulated blood. The spleen and left kidney were also ruptured. The man died a few days after the accident.

Case 2. Travers[4] observed a case of laceration of the pancreas at St. Thomas' Hospital. An intoxicated woman was knocked down by the wheel of a stage-coach, which, however, did not pass over her. She lived only a few hours. Several ribs were fractured, the pancreas was found completely torn through transversely, the liver was lacerated, and much blood was effused.

Case 3. Störck[11] mentions the case of a woman who was run over by a coach, and who died within a few hours. The pancreas was found completely torn in two, and embedded in a large mass of semifluid blood. Several ribs were fractured, and the liver was also ruptured.

Case 4. M. Le Gros Clark[12] observed an instance of subcutaneous laceration of the pancreas, which occurred in a lad who was also the subject of other severe injuries that speedily proved fatal.

2. *Penetrating Wound of Abdomen, with Protrusion of Pancreas.*—Case 5. Laborderie[13] reports the case of a girl, aged ten, who had fallen, while running, upon an open pocket-knife, which inflicted a wound 2 ctm. (three-fourths of an inch) below the lower border of the ribs, and three fingers' breadth to the right of the median line, extending outward for 1½ ctm. (half an inch), almost

horizontally, with a little inclination from above downward. The pancreas was found strangulated in the wound so tightly that not a drop of blood escaped. The author believed that the prolapse was caused by the screaming of the patient. The duct of Wirsung and the vessels escaped injury. The abdomen was painless on palpation, and there were no signs of internal hæmorrhage. The knife had entered the abdomen under the lobus Spigelii of the liver, and in its course reached the stomach, cut through the gastro-hepatic omentum, and then penetrated between the liver and pylorus to the pancreas, without injuring any of the many large vessels in the locality through which it passed. An attempt to replace the gland was only partially successful. The mass was transfixed and tied at its base with a double ligature, and the portion outside of the ligature was removed with a knife. After this procedure nausea and vomiting set in, which, however, soon subsided. The wound was treated by the use of cold-water applications. On the third day the patient complained of being chilly, and the abdomen became somewhat tympanitic and tender on pressure. These symptoms soon subsided, and the ligatures sloughed through, leaving a granulating surface which healed in fourteen days. Recovery was complete in three weeks.

Hyrtl and Klebs are incredulous as to the prolapse of the pancreas in this case; they believe that the mass which was ligated and removed was not the gland, but a portion of the omentum. Nussbaum,[14] however, in speaking of visceral injuries of the pancreas, states distinctly that in penetrating wounds of the abdomen, in the region of the pancreas, this organ manifests a tendency to prolapse, and that this circumstance facilitates the treatment, as it protects the peritoneal cavity against infection by plugging the wound, and at the same time affords better access to the bleeding vessels.

Case 6. Dargau[15] saw a case in which the pancreas protruded through a wound five inches in length, between the last two false ribs, on the left side. The patient was a negro, who had been injured fourteen hours before he came under treatment. The pancreas was replaced, the wound closed, and the patient made a good recovery.

Case 7. Caldwell[16] reports the following remarkable case: In 1816 a negro was stabbed in the left side, and "an oblong body, between three and four inches in length, was observed to have protruded." Drs. Roberts, Beard, and Caldwell supposed the protruded part might be mesentery, omentum, or lung substance; but, on a more minute examination, the opinion was changed to the belief that it was the small extremity of the pancreas. The protruding part was in a gangrenous condition, and was removed with the knife. The patient soon recovered. The gentlemen who treated the case, "thinking it almost impossible that the pancreas could escape through a part of the diaphragm and between the ribs," made a critical examination of the part removed, which resulted in their *thorough conviction* that the tissue removed was a portion of the pancreas.

Case 8. Kleberg,[17] who, together with Dr. Wagner, Jr., examined the specimen of pancreas microscopically at the time, reports the following case: A. S., aged sixty, a discharged soldier, of powerful frame and a drinker, was surprised while committing a burglary, and was cut in the abdomen with a knife, entering from below upward while he was stooping over. He was carried into the surgical wards of the hospital at 6 A.M., having a cut in the abdomen, running horizontally, about twelve inches in length, between the navel and lower border of the ribs on the right side. Protruding from the wound was a brown-red body, about three inches long by two inches in width, of a doughy consistence and covered by a smooth membrane. Immediately after entering the hospital he had a normal passage through the bowels; pulse 72; no pain. The stomach, intestines, and liver could be excluded on examining the appearance and physical properties of the projecting body. There was no fat, as would have been the case had it been the omentum of such a corpulent person. The prolapsed body was compact and homogeneous, could not be separated into layers, and presented no dilated vessels. It was, therefore, taken to be the head of the pancreas. As reposition of the protruding part did not appear advisable, on account of a possible constriction, and as the consequences could not be foreseen, the part was fixed in the wound with two Karlsbad needles, which were passed through the sides of the wound and the protruding part; a silk ligature was then passed around the pedicle of the protruding part, the end of which was cut off with one stroke of the knife; the profuse oozing of blood was stopped by tightening the ligature. The stump was touched with solution of the sesquichloride of iron, and cold applications were made over the whole abdomen. There was neither fever, peritonitis, nor disturbance of digestion in the course of the recovery. The needles and sutures were removed on the fourth day; the stump had become adherent to the edges of the wound. The stump and ligature came away on the tenth day. The patient left the hospital twenty days after admission, with a three-cornered depressed scar. As he was perfectly well-nourished during the entire time, it is probable that the caudal extremity of the gland was removed, and that the portion of the gland remaining, with the excretory duct, performed the functions of the organ adequately.

The following two cases are from the "Medical and Surgical History of the War of the Rebellion," Part II., vol. ii.; "Surgical History," p. 158:

Case 9. Assistant Surgeon J. G. Thompson, Seventy-seventh New York, reports the case of "a soldier, name unknown, who was wounded at Cedar Creek, October 19, 1864. The ball entered the right side, below the ribs, and emerged on the left side. He was removed to the Taylor Hospital, at Winchester. While straining at stool, two days subsequently, a hernia of the pancreas occurred of the size of a hen's egg. A silver wire was passed about the pedicle by which it was attached, and was twisted tighter each day for about a week, until it became very small, and was snipped off with the scissors. No special symptoms supervened, and by the last of November the patient was in a fair way toward recovery, and was moving about the hospital. In December he was still doing well."

Case 10. Private William Freshwater, Co. F, Sixty-sixth Ohio, received wounds of the abdomen, left forearm, and neck at Port Republic, June 9, 1862. He was conveyed to Fort Royal, arriving on the 13th, and on the 14th was sent by rail to Washington, and admitted, on the 15th, to Judiciary Square Hospital. He was placed in a ward under the charge of Acting Surgeon D. W. Cheever, who states that "a ball had entered, one and a half inch outside the left nipple, on a level with the seventh rib, and could be felt under the skin near the spinous process of the last dorsal vertebra. Some viscus, thought to be the lower tip of the lung, protruded at the wound. He died in two days (June 17th) with symptoms of peritonitis. Post-mortem: The ball had pierced the diaphragm without touching the lower lobe of the lung; there was no perforation of the intestines, but they were glued together by peritoneal inflammation. The pancreas protruded at the wound."

3. *Gunshot Wounds.*—The only cases of gunshot wounds of the pancreas that I have been able to find are reported by Otis (*ibid.*, p. 159).

Case 11. Private J. Koprieau, Co. B, Fifty-first New York, aged thirty-two, was severely wounded at the battle of the Wilderness, May 5, 1864, and was at once taken to the field hospital of the Second Division, Ninth Corps. As the patient could not talk English, the history of the case is quite imperfect. Assistant Surgeon J. C. McKer furnished the following description, which I have abbreviated without omitting essential facts: The patient came under his care May 25, 1864, when it was ascertained that he was suffering from a gunshot wound of the back, the ball having entered about six inches to the left of the spinal column, and having passed below the eighth or ninth rib. It was evident that the ball had entered the abdominal cavity, but its course could not be ascertained. The patient's general health was apparently

good and he seemed to suffer but little pain from the injury. Appetite good, bowels regular, urine slightly suppressed and somewhat highly colored. Pulse normally full, but slightly irritable. The patient was ordered quinine, whiskey, nourishing diet, and two doses of acetate of potassa. No noticeable change appeared for about one week, when a severe hæmorrhage occurred, apparently venous, from the external wound, which was soon arrested by the use of compresses and styptics. About six hours afterward a quantity of urine was voided, which was thickly mixed with blood. These hæmorrhages continued to recur two, three, and four times daily till death, the urinary discharge being very frequent and always bloody. Death occurred June 5, 1864. Post-mortem examination revealed the following: A Minié ball entered at the middle portion of the eighth rib, fractured the same, passed through the centre of the spleen toward the pancreas, penetrating this also in a nearly transverse direction, and (probably a few days before death) sank toward the splenic artery, tearing it, and then lodged at the point of origin of this artery from the cœliac axis; the lung was found emphysematous. The ball was found embedded in the pancreas in a pouch between the sloughing artery and vein. The specimen is

Fig. 2747. -Gun-shot Wound of the Pancreas.

preserved as a wet preparation in the Army Medical Museum, and is marked No. 2430 (Fig. 2747).

Case 12. Corporal A. B. Jones, Co. D, Fifth Vermont, aged twenty-seven, was wounded at the battle of the Wilderness, May 10, 1864, and lay on the battlefield one day and night; was then removed to the field hospital, thence carried by boat to Washington, and jolted over a rough road of two miles to the Lincoln Hospital, which he reached about two o'clock in the morning of the 25th. He was seen a few hours afterward by Acting Assistant Surgeon T. L. Leavitt, who found him suffering great agony. On examination it was found that the ball had entered one line to the left of, and below, the ensiform cartilage, passing through the abdominal cavity and making its appearance under the skin just above the crest of the ilium, posteriorly, where it was excised at the field hospital. Pulse quick and exceedingly feeble, abdomen distended and tympanitic. Opium was administered, and the patient took liquid food freely. About noon of the same day the symptoms improved, the wound suppurating nicely. About four o'clock the patient was conversing with the nurse, apparently in good spirits, without very great pain, and in about five minutes afterward was *in articulo mortis*. The autopsy showed the ball to have perforated the inferior curvature of the stomach, and, strange as it may seem, although an orifice was made directly through the walls of the stomach large enough to readily admit two fingers, no inflammation, or even congestion, could be detected, except in the immediate locality of the wound, which was beginning to suppurate. Evidently the stomach was also uninjured in its functional capacity, as was witnessed by the reception and digestion of food during life. Some branches of the gastric artery were severed, and about an ounce and a half of dark uncoagulated blood was found. The pancreas was perforated at about its middle, but, except in the immediate track of the ball, gave evidence of no departure from its healthy standard; the intestine and colon were pushed aside during the passage of the ball and were uninjured; the omentum was found in a state of partial decomposition and closely adherent to the small intestine. The liver and spleen were healthy. General peritonitis had prevailed, and was undoubtedly the cause of death. In this case life was sustained for a period of fifteen days, notwithstanding the serious injury of a vital organ and the exposure to the most unfavorable circumstances and depressing influences.

Case 13. Private William P. B., Co. A, Forty-fourth Georgia, was wounded near Fort Stevens, in General Early's demonstration on Washington, July 12, 1864, by a cylindrico-conical musket-ball, which entered below the spine of the left scapula, an inch from the shoulder-joint, and penetrated the chest. He remained a prisoner on the field, and was conveyed to Lincoln Hospital, a few miles distant, being admitted on July 14th. He was examined by Dr. Leavitt, who found that emphysema extended over the entire left chest, that respiration was painful, but not otherwise difficult, and that there was paralysis of motion of the left arm. There was little change in the progress of the case until the 18th, when the pain in the side became severe, and was somewhat relieved by sinapisms. The following day there was dulness over the posterior and left part of the chest, also extreme dulness in the præcordial region, and the heart was forced over to the right side. There was dulness, too, at the base of the right lung, with indistinct respiratory murmur. On the 20th, jaundice was very pronounced. On the 21st, profuse hæmorrhage from the nose and mouth occurred, the bleeding coming apparently from the lung. The pulse at this time was very weak and thready, and jaundice was extreme. On the 22d there was much pain in the left side, dyspnœa, consciousness perfect, pulse failing; death took place at noon, July 24, 1864, twelve days after the injury. At the autopsy the wound was traced from the entrance in the scapula through the fractured fifth rib, the track passing downward, inward, and backward, through the lower lobe of the left lung, the diaphragm, and the left lobe of the liver to the head of the pancreas, where the ball was found lodged in the head of the viscus, at the angle formed by the cœliac axis with the aorta. The lower lobe of the right lung was hepatized; the left lung carnified, collapsed, and compressed by a large accumulation of black fluid blood. The pancreas was rather large—seven inches long; weight, with ball, five ounces. There was nothing abnormal in its appearance, except the presence of the foreign body. On examining the pancreas microscopically, no deviation from the normal structure was found in sections made from the tissue taken from the left end or tail of the viscus and from the middle part. In close contiguity to the ball was a fine net-work of fibrillated tissue. As hardened in alcohol, the specimen offers no indication of vascular engorgement having existed. The specimen is preserved in the Army Medical Museum, and is marked No. 2884 (Fig. 2748).

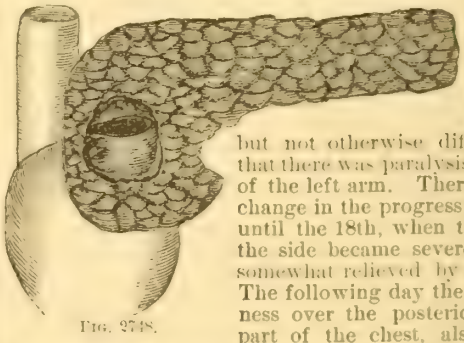

Fig. 2748.

Remarks.—In not a single instance of the thirteen cases

of injury of the pancreas, as reported above, did symptoms during life first point to this organ as the seat of lesion. In all cases in which the result was fatal, death was not attributable to the visceral lesion of the pancreas, but was always referable to injury of some adjacent organ. With the exception of cases of prolapse of this organ through a penetrating wound of the abdomen, the diagnosis and treatment of injuries of the pancreas will come under the observation of surgeons only in an incidental manner, in the treatment of more tangible and graver lesions within the abdominal cavity. Contusion and laceration of the pancreas as independent conditions are not necessarily fatal injuries, and spontaneous recovery may take place, followed by absorption of the crushed portion of the organ, and atrophy of that portion of the gland which has become physiologically detached from the intestinal tract by the injury or its direct consequences. Crushing of the pancreas is usually not attended by hæmorrhage, and in laceration of the organ the danger from this source is much less than in cases of incised wounds.

Treatment.—As modern surgery teaches not only the justifiability, but the absolute necessity, of treating penetrating wounds of the abdomen, where visceral injury is suspected, by abdominal section, the surgery of the future will undoubtedly deal with contusions and lacerations of the pancreas in connection with visceral injury of some of its adjacent organs. If, in exploring for injuries in this region, the pancreas should be found extensively crushed, it would be good surgery to remove the crushed portion after preliminary ligation of the organ on each side of it. Ligation of the pancreas can be safely done with a single catgut or silk ligature, as the friable texture of the organ will permit of burying the ligature deeply, a circumstance which will guard against slipping of the ligature. In not a single instance in which this method of ligation was resorted to in my experiments on animals was secondary hæmorrhage observed from inefficiency of the ligature. If the pancreas is lacerated, each end of the organ should be ligated for the purpose of arresting or preventing hæmorrhage, as well as to guard against extravasation of pancreatic juice into the abdominal cavity.

The results obtained by experiments on animals, as detailed before, have demonstrated in a satisfactory manner that normal pancreatic juice, when brought in contact with the peritoneum, does not produce inflammation, but is promptly removed by absorption. In the experimental work we always had the advantage of dealing with a normal serous surface, the absorbing capacity of which had not been impaired by antecedent pathological conditions, as would in all probability be the case in the operative treatment of injuries of the pancreas. At the same time there can be no doubt that the presence of crushed pancreatic tissue and pancreatic juice in the peritoneal cavity, after abdominal section, would greatly enhance the danger of traumatic infection. For this reason, if for no other, the former should be removed, and the escape of the latter should be prevented by ligation of the pancreas on the side, or each side, of the crushed or lacerated portion. The cases of protrusion of the pancreas seem to establish the fact that a portion of this viscus may be separated by violence from the splenic artery and other important attachments, and may become prolapsed through an external wound, and under such circumstances can be removed without serious consequences. In most cases the prolapse followed some time after the injury, from a sudden increase of intra-abdominal pressure, as coughing or straining at stool. Klebs' and Hyrtl's objection to the possibility of a hernia of the pancreas, can find a plausible support only by assuming that the relations of the pancreas have not been disturbed. If, by the violence which produced the penetrating wound, the attachments of the organ are severed, or in case the attachments have been abnormally loose, or the duodenum is supplied with a long mesentery, there is no tenable reason why the pancreas should not occasionally be found protruding through the external wound. Cases are on record in which the pancreas constituted one of the contents of a diaphragmatic hernia, and an instance is reported where it formed a part of the intussusception in a case of invagination of the bowel (Blandl).

The treatment of prolapse of the pancreas will depend upon the pathological condition of the viscus at the time the patient comes under the care of the surgeon. If the prolapse is recent and the organ presents no indications of inflammatory or other changes, it should be thoroughly disinfected and replaced. It is of the greatest importance not to use any violence in effecting reduction, as irreparable damage may be inflicted by resorting to more than the gentlest force. When reduction is not readily accomplished, the wound should be enlarged. If the pancreas is in a condition of inflammation or gangrene, the parts should be thoroughly disinfected and the organ pulled farther into the wound until healthy tissue is reached, when a ligature may be applied and the diseased portion removed with the knife or scissors. After another thorough disinfection the stump is dropped into the abdominal cavity and the external wound closed. Thorough primary removal of infected tissue is the only safety against subsequent extension of the infection to the peritoneal cavity, and the only guarantee for primary union of the abdominal wound.

In gunshot wounds of the pancreas we have no guiding symptoms upon which to base even a probable diagnosis. The point of entrance and exit of the ball, and its probable course, are the only facts which may point to the pancreas as one of the injured organs. In four of the five cases the projectile penetrated posteriorly in the space between the angle of the left scapula and the angles of the ribs, and passed through the diaphragm and the solar plexus; in one the ball entered anteriorly near the tip of the xiphoid cartilage, and was believed to have passed through the stomach.

It is a notable and somewhat significant fact that, in all cases in which life was prolonged for more than twelve days, the pancreas appeared to have undergone but little or no pathological change in the vicinity of the visceral wound. Although in all cases the track of the ball did not remain aseptic, the inflammatory changes did not materially affect the parenchyma of the gland.

In Case 13 the formation of a capsule around the bullet had already been initiated, and if the patient had lived there is every reason to believe that the foreign body would have become encysted in the parenchyma of the pancreas. Gunshot injuries of the pancreas, when they come under the observation of the surgeon as an independent lesion, or as a complication of other visceral injuries, in cases of penetrating wounds of the abdomen treated by laparotomy, should be managed in the same way as a contusion or laceration of the gland. The results obtained by the author's experiments have shown that if only a comparatively small portion of the pancreas remains in physiological connection with the duodenum, this portion of the gland retains its normal structure and its physiological function, which, in all of the experimental cases, was found adequate to supply the requisite quantity of pancreatic juice necessary for the maintenance of normal digestion. While the surgeon may unhesitatingly remove the tail and a portion of the body of the pancreas without fear of any immediate or remote ill-effects, great care must be exercised in operating in the vicinity of the head of the pancreas to preserve the integrity of the common duct, and as much of this portion of the organ as may appear compatible with the condition which necessitated the operation.

The results of the experiments made with a view to ascertain how much of the mesentery of the duodenum can be detached without causing gangrene of the bowel, have been such as to encourage a conservative plan of treatment when operating in close proximity to the intestine. The observations made in this direction have shown that it is comparatively safe to detach a portion of the mesentery, even to the extent of from one to three inches, a procedure incomparably easier and much safer than enterectomy, combined with partial excision of the head of the pancreas. I wish again to emphasize the fact that com-

plete extirpation of the head of the pancreas with the common duct is never justifiable, and that operation upon this portion of the gland for injury or disease must be limited to partial excision of the head, with preservation of the common duct.

Acute Pancreatitis.—Acute idiopathic pancreatitis is an exceedingly rare affection; only a few well-authenticated cases of the disease have been reported. A brief consideration of this affection is necessary in connection with our subject, for the purpose of calling attention to a few of the most constant and prominent symptoms which characterize the disease, inasmuch as all suppurative lesions of this organ, which are of special interest to the surgeon, are preceded by inflammation. The disease originates either primarily in the inter-acinous connective tissue of the organ as a pancreatitis, or it occurs as a secondary disease from extension of a peri-pancreatitis to the substance of the gland. Haller and Klob have given an accurate clinical description of a case observed at the Allgemeines Krankenhaus, in Vienna, with a careful account of the post-mortem appearances.[18]

Case 1. A gilder, sixty-three years of age, had been suffering from indigestion, which was referred to a defective stomach digestion. Flatulency and vomiting were prominent symptoms. The patient was anæmic, and presented a cachectic appearance; tongue slightly coated; anorexia; epigastrium tympanitic and tender on pressure. Vomiting of a thin, yellow, bitter fluid. Slight elevation of temperature; pulse 90; lower extremities œdematous. The same evening vomiting, collapse, and great pain in epigastrium, extending over the abdomen. During the night obstinate vomiting, traces of blood in the ejected matter; urine dark-colored, contained no albumen. Next day the vomiting ceased, but collapse increased, and was followed by death toward evening. The autopsy revealed serous infiltration of the gray matter of the brain and of the lungs. The stomach was collapsed, its mucous membrane bulging. The posterior wall of the stomach was perforated in three places, the openings being as large as a pea and funnel-shaped, with the larger extremity directed toward the peritoneal surface. The edges of these perforations were quite friable, discolored, and continuous with a fetid abscess cavity, which extended from the posterior surface of the stomach to the spinal column, and from the spleen to the pylorus, in which the pancreas was found as a grayish, discolored, flabby, thin, and exceedingly fragile mass infiltrated with pus. In front of the anterior wall a fringed portion of the bursa omentalis was found, and on the upper border the arteria and vena lienalis were seen; the latter was filled with a thrombus. Examined under the microscope, the parenchyma of the gland showed that the cells were degenerated, being distended and turbid; the acini were separated, at some places collapsed, and the spaces between them contained granules and large globules of fat.

In this case the course of the disease was quite acute, terminating in diffuse suppuration and death, after an illness lasting only sixteen days. The absence of disease in any of the adjacent organs, and the advanced pathological changes in the gland itself, pointed to the pancreas as the primary starting point of the inflammation.

Case 2. Mayo[19] also gives an interesting description of a fatal case of subacute pancreatitis, with the post-mortem appearances. The patient was a lady, twenty-one years of age. When five months advanced in pregnancy she lost her usual healthy appearance, and gradually became very anæmic. She complained of great thirst, and also suffered much from pain in the epigastric region, which was sometimes so severe as to oblige her to retire to her apartment. After her delivery the thirst remained, and the weakness and paleness increased. Her state and symptoms were like those of persons who have lost large quantities of blood. About five days before death the stomach became irritable, and nothing but rennet-whey in small quantities was retained. She died five weeks after delivery. Upon inspecting the body the viscera generally were found pale and bloodless. Besides serous effusion on the membranes of the brain and on the peritoneum no pathological changes were observed, except that the pancreas was throughout of a deep-red color, which contrasted very remarkably with the bloodless condition of other parts. It was firm to the touch externally, and when an incision was made into it the divided lobules felt particularly firm and crisp.

Case 3. Haidlen[20] reports the following case from Fehling's private practice: A woman, aged thirty-three, became pregnant, and during the period of gestation had considerable gastric disturbance and headache. She remained well three weeks after delivery, when there was some hæmorrhage. A little latter she had two attacks of pain in the region of the stomach, and five and a half weeks after delivery she had a very severe attack of pain in the pyloric region, accompanied by vomiting. There was no elevation of temperature, the pulse was 100 to 104, and regular. The epigastric region was sensitive to pressure, but there were no symptoms of peritonitis; the skin was pale and not jaundiced. The patient seemed somewhat collapsed. In the forenoon of that day she seemed worse, the skin was paler, the pulse more rapid, and the vomiting had ceased. Physical examination showed marked swelling of the abdomen, and great tenderness over the pyloric region. There were no symptoms of pelvic disturbance. On the following day the patient was better, but the symptoms returned, and she died, in collapse, in ninety-six hours. The autopsy showed that there was no peritonitis, though a small amount of a dirty, bloody-looking fluid was found in the lower part of the peritoneal cavity. The organs, with the exception of the pancreas, had undergone no considerable changes. The latter was larger, thicker, and broader than normal, and only in a few places was its normal color retained; it was changed almost entirely to a brownish-red, blood-suffused mass, containing a small clot of blood on the anterior surface, in contact with the mesentery, but there was no perforation anywhere. The adjacent portion of the mesentery was suffused with blood. Ziegler, who made the microscopic examination, pronounced the case one of acute pancreatitis, and stated that the duct of Wirsung was somewhat dilated, and that he also found small-celled infiltration of the pancreatic tissue.

Remarks.—The immunity of the pancreas from disease is attributed by Gross[21] to the singular structure of this organ, to its concealed situation, and to the absence of everything like a proper envelope.

The first two cases may serve as types of the two distinct forms of inflammation of the connective tissue of the pancreas, the suppurative and interstitial. Another form, the parenchymatous variety, is occasionally met with in the puerperal state, in cases of typhoid fever, pyæmia, yellow fever, and other acute infectious diseases, the post-mortem appearances of which are illustrated by Case 3. In this form the pancreas is red, swollen, and œdematous. Microscopically, in this variety the most prominent lesion consists in swelling and undue granulation of the glandular epithelium, and in hyperæmia.[22]

In the first case the symptoms were acute, and the disease terminated in death in the short space of sixteen days. The suppurative inflammation beginning in the interstitial tissue involved the entire gland, and extended by continuity to the para- and peri-pancreatic tissue, giving rise to an acute diffuse abscess. The termination is sufficient evidence that the inflammation was produced by a specific cause—the pus-microbes. In the second case the primary seat of the inflammation was the same, but the process assumed a subacute character, and terminated in a hyperplasia of the connective tissue. The most prominent symptoms in both cases were severe pain in the epigastrium, progressive anæmia, and vomiting. In both instances the pain assumed a neuralgic character; it was referred to the region of the cœliac plexus, radiating thence over the abdomen. Neuralgia of the cœliac plexus is one of the most constant symptoms of disease of the pancreas, as Klebs alludes to it as being present eleven times in fifteen uncomplicated cases. Atrophy of the cœliac plexus is mentioned by Klebs as the cause of the neuralgia.

A high degree of anæmia was apparent in both cases,

from the extensive area of tissue which was found in an œdematous condition, as well as from the statement of Mayo, that his patient presented the appearance of a person who had suffered from repeated and severe hæmorrhages. As the pancreas is not concerned directly in the function of hæmatogenesis, we can only explain the constancy with which this symptom is mentioned by assuming that the anæmia was due to imperfect digestion and assimilation, caused by an arrest of pancreatic secretion. Vomiting was an early and troublesome symptom in the first case. No reference is made to the condition of the stools in either case. The presence of undigested fat in the stools is, however, one of the rare symptoms of disease of the pancreas. Klebs states that in three cases where this symptom was present, the duct of Wirsung was either entirely or partially obliterated, while in a number of cases where the duct was in the same condition the stools remained normal.

The *treatment* of acute pancreatitis will consist in careful regulation of the diet, and in the administration of such remedies as will have a decided antiphlogistic effect during the acute stage, to be followed by measures calculated to aid the digestion, and to restore the blood to its normal condition.

Chronic Interstitial Pancreatitis, or Sclerosis of the Pancreas.—This lesion consists in an increase of interstitial connective tissue, which may affect the entire organ or remain limited to some particular portion, more especially the head of the gland. During the early stages of the disease the organ is enlarged, more vascular and firm, while later the cicatricial contraction of the interstitial deposit produces atrophy of the parenchyma, with a corresponding diminution in the size of the organ. This form of inflammation of the pancreas is of particular interest to the surgeon, as the cicatricial contraction may produce secondary changes in the pancreatic or bile-ducts, an occurrence which would indicate a resort to surgical measures for the relief of the immediate symptoms due to retention of one or the other of the secretions.

The causes which produce sclerosis are often obscure, but usually referable to some antecedent affection in some of the organs adjacent to the pancreas, as the peritoneum, subperitoneal tissue, duodenum, or common bile-duct, or pancreatic lithiasis, where the primary cause is in the pancreas itself. The connective-tissue proliferation destroys the parenchyma by compression, and constitutes one of the causes of stenosis of the pancreatic duct.

Case 1. Todd[23] observed this condition in a girl fourteen years of age, in whom the head of the pancreas and the neighboring connective tissue were the seat of the disease. This case is of unusual interest, as the contraction of the cicatricial tissue produced obstruction of the common bile-duct by compression, which caused a dilatation of the ducts behind the seat of obstruction, converting them into a large sac, which was located behind the duodenum and reached downward as far as the sacrum, and laterally from one kidney to the other.

Case 2. O. Wyss[24] gives a description of another case in point. A man, fifty years of age, became deeply jaundiced, and had three or four loose, clay-colored stools daily. He died after an illness of four and a half months' duration. At the autopsy the liver was found enlarged and of a deep olive-green color. The gall-bladder and bile-ducts were much dilated and contained inspissated bile. The common bile-duct entered the head of the pancreas four centimetres (1½ inch) before its termination in the duodenum, and traversed the indurated portion of the organ for a distance of two and a half centimetres (nearly one inch). At this point the duct was found so much contracted that only a fine probe could be passed through it. The common pancreatic duct was dilated, as were also its branches, which at some points were enlarged in the form of cysts, varying in size from that of a hemp-seed to that of a hazel-nut. Wyss attributed dilatation of the common duct to compression by one of the smaller cysts in the head of the pancreas, but it is more than probable that the condition was due to the cirrhotic contraction of the organ.

That icterus is not a constant symptom of this condition is illustrated by the following case, reported by Claessen :

Case 3. A man, thirty years of age, had been subject to indigestion, constipation, and severe pain in the epigastrium for several years. After his death it was shown at the autopsy that the head of the pancreas and the acini were yellow, and the inter-acinous connective tissue abundant, and yet the duct of Wirsung and the bile-duct were not contracted.

Remarks.—The surgical treatment of sclerosis of the pancreas can apply only to secondary lesions which result from stenosis of the pancreatic or bile-ducts, and distention of these passages by accumulation of the secretions. Such an occurrence is most apt to take place when the disease affects the head of the pancreas, as the cicatricial contraction in this locality may cause stenosis of either the duct of Wirsung, the common bile-duct, or both. Any operative interference in these cases will be of necessity limited to an attempt to secure an artificial outlet to the retained secretion. The restoration of the permeability of the natural outlet by any method of treatment is entirely out of the question.

The tendency of the disease is to aggravate the obstruction as cicatricial contraction progresses. The history of all these cases pointed to an impairment of digestion as the principal clinical feature in each instance. It is, therefore, of considerable importance to examine carefully into every obstinate and obscure case of indigestion, with a view to eliminate the possibility of organic disease of the pancreas as its cause. In cases of permanent retention of the bile or of the pancreatic juice, caused by cicatricial compression of the bile-duct or of the pancreatic duct, the earlier symptoms will have reference to a history of obstinate indigestion, progressive in its character. If, on the other hand, the obstruction is produced by the impaction of a calculus, the previous history will point to attacks of sudden and severe pain, and other symptoms indicative of the passage of a calculus along the excretory duct.

In the case of biliary retention-cysts, as represented in Case 1, the establishment of an external biliary fistula would result in a permanent fistula, as the impermeability of the bile-duct would preclude the possibility of re-establishing, by any kind of an attempt, the normal communication between the dilated bile-passages and the intestine. Such an operation would remove only the urgent symptoms due to retention and absorption of bile, but would leave unchanged the primary cause of the retention, and would exclude, permanently, the bile as a digestive fluid from the alimentary canal. As the obstruction is permanent and irremediable, the operation which suggests itself as fulfilling the urgent indications, as well as preventing remote ill consequences, is the formation of a new outlet for the bile into the intestinal canal, by establishing a permanent fistula between the duodenum and the gall-bladder, or between the duodenum and the dilated bile-ducts. Duodeno-cholecystostomy has a future in all cases of permanent and incurable obstructive lesions in the bile-duct, and will become an established operation as soon as it has been perfected by an improved technique.

My experiments on animals have demonstrated that physiological detachment of any portion of the pancreas is invariably followed by degeneration and atrophy, irrespective of the particular method by which this detachment is effected; consequently it is only reasonable to assume that permanent obliteration of the pancreatic duct by cicatricial contraction is always followed by degeneration of the parenchyma of the gland on the distal side of the seat of the obstruction.

It is on this account that stenosis of the pancreatic duct is seldom followed by dilatation of the ducts to any considerable extent on the distal side of the constriction, and even more seldom by the formation of a cyst. A retention-cyst can result from obstruction only so long as secretion has not been entirely suspended, and when, at the same time, absorption of the pancreatic juice does not take place, on account of further extensive patholog-

ical changes in the structures which perform this function, when the gland is otherwise in a normal condition.

As the physiological detachment by obstruction of the common pancreatic duct, caused by cicatricial contraction, is invariably followed by complete destruction of the parenchyma of the contributory portion of the gland it is evident that the surgical treatment of a cyst of the pancreas in such cases can be indicated only when the swelling becomes, in itself, a source of serious inconvenience and pain. The proper treatment in all such cases consists in the formation of an external pancreatic fistula by abdominal section. There is no danger, in such instances, of the fistula remaining permanently, as the glandular tissue which might remain at the time of operation will, in the course of time, disappear by degeneration and absorption. As in animals, so in man, the health of the individual after gradual atrophy of the pancreas will depend upon the physiological capacity of vicarious organs, in each particular case, to assume the functions of the pancreas.

In recapitulation it may be stated that cirrhosis, or chronic interstitial pancreatitis, sometimes produces stenosis of the bile-duct or pancreatic duct; and that, when the obstruction is followed by retention of the secretions, if the retention is of the bile, an operation always becomes necessary, and should consist in the establishment of a new outlet for the bile into the duodenum; while the formation of an external pancreatic fistula, in cases of cyst of the pancreas, becomes necessary only when the presence of the swelling has in itself become a source of sufficient pain and discomfort to warrant treatment by abdominal section.

Gangrene of the Pancreas.—One of the terminations of acute inflammation of the pancreas is gangrene. Cases have been reported in which spontaneous recovery followed elimination of the necrosed organ through the alimentary canal. If spontaneous recovery in this condition is possible, it would seem plausible that a timely removal of the necrosed organ by surgical interference might add to the chances of recovery; consequently we shall add gangrene as one of the diseases of the pancreas which should be treated by operative measures.

Case 1. Trafoyer, of Hernals, treated a patient for what appeared to be a passage of gall-stones. During the course of the disease the patient passed, per rectum, a solid mass, the nature of which could not be readily ascertained. This mass was sent to Rokitansky for examination, who found in it gall-stones, and a large part of the pancreas, in which the duct was plainly visible. Rokitansky[25] believed that a portion of the pancreas had become invaginated into the duodenum and had sloughed. Nothing could be ascertained concerning the subsequent history of the case.

Case 2. (Reported by Chiari.[26]) A woman, aged forty-six, had been subject to occasional attacks of pain in the stomach. She was seized suddenly with severe pain in the abdomen, followed by vomiting and other symptoms of diffuse peritonitis. Toward the close of the disease she had a chill, and vomited a black, very offensive fluid. At the necropsy the pancreas was found separated from all its attachments, and of a brownish color. The duodenum and transverse meso-colon were perforated, the bursa omentalis contained an offensive sanious fluid, consecutive to diffuse peritonitis. The pancreatico-duodenal artery was eroded.

Case 3. (Ibid.) Patient, a man thirty-eight years of age, was attacked with symptoms indicative of cholelithiasis, followed by symptoms of obstruction of the bowels which lasted for a number of days, and subsided only after the passage, per rectum, of the greater portion of the necrosed pancreas. The patient recovered.

Case 4. Israel[27] reports a case of necrosis of the pancreas in a patient suffering from diabetes mellitus. The autopsy showed a fluctuating tumor between the stomach and transverse colon, which revealed itself as a cyst, with thick walls, firmly adherent to the intact head of the pancreas. The cyst contained three hundred cubic centimetres of a clay-colored fluid, in which crystals of hæmatoidin and the necrosed body and tail of the pancreas were found. Israel attributes the cause of the destructive process to an inflammation of the peri-pancreatic tissue, which had given rise to repeated hæmorrhages into and around the pancreas. The disease of the pancreas, he holds, was not the cause, but the effect, of the diabetes.

Case 5. Prince[28] reports the following case: A man, twenty-two years of age, during a violent exertion, was taken with severe pain in the abdomen, followed by pain in the epigastric region, vomiting, chills, and a sensation of great oppression and uneasiness. In a few days diarrhœa followed, and during the third week he died. At the autopsy the anterior abdominal wall was found firmly adherent to the omentum and intestines; between the intestinal convolutions a chocolate-colored fluid was found. The greater portion of the pancreas was destroyed and converted into a black, gangrenous mass. The mesentery of the upper portion of the jejunum, which was adherent to the lower margin of the transverse colon, showed in its folds an accumulation of thick, greenish pus.

Case 6. (Reported by Rosenbach.[29]) A woman, fifty-seven years of age, otherwise in good health, had suffered some time before from pain in the abdomen and constipation, but was soon relieved. Three weeks before she came under observation of the reporter the same trouble returned. The bowels had not moved for three days; there was frequent vomiting of greenish fluid, and great weakness. On examination a fluctuating tumor, the size of a child's head, was detected in the epigastric region, behind the stomach, which was considerably dilated. The tumor was immovable. As the symptoms pointed to intestinal obstruction of some kind, and failed to be relieved by enemata, it was decided to perform laparotomy, to which the patient readily consented. The abdomen was opened through the median line, but, as the tumor was not rendered sufficiently accessible, a transverse incision was made over the part most prominent. After division of the meso-colon an effort was made to enucleate the tumor, but the inflammatory adhesions were so firm that the attempt had to be abandoned. An effort was then made to push the stomach upward, but this likewise failed. During these manipulations the tumor ruptured, and a fluid, at first clear, then turbid and offensive, poured out. The fluid was removed without soiling the peritoneal cavity. The sac was then stitched to the margins of the wound. After suturing the remaining portion of the external incision, the opening in the sac was enlarged and drained. The patient died of shock six hours after the operation. At the autopsy the necrosed pancreas was found in the sac. The abscess cavity extended behind the stomach and lesser omentum. The intestinal obstruction was caused by pressure of the swelling upon the small intestines.

Remarks.—The pancreas may constitute one of the component parts of the intussusceptum in cases of invagination of the bowels, as such a case has been reported by Bandl, and the specimen examined by Rokitansky furnishes a similar illustration. The second case reported by Chiari may have been of a similar nature, the invaginated portion having sloughed with the remaining part of the intussusceptum, leaving the continuity of the bowel unimpaired by adhesions at the point of separation. If, in this instance, the necrosis was due to inflammation, we can only infer that the para-pancreatic abscess ruptured into the bowel, that the necrosed portion of the pancreas was eliminated in this manner, and that subsequently the opening in the bowel closed. Constipation was a prominent symptom in a number of these cases, and in Rosenbach's case the symptoms of obstruction were so well marked that it was decided to perform laparotomy for its relief. This last case is also of great interest, as during life the existence of a tumor in the region of the pancreas was diagnosticated.

Modern surgery deals extensively with abdominal section for the relief and cure of peritonitis and intestinal obstruction. In searching for the cause of either of these conditions during laparotomy, the pancreas should not be forgotten, and if it is found that the primary disease

is located in or around this organ, radical measures should be adopted whenever such a course appears practicable.

Whenever the sac can be stitched to the external incision this should be done, and the sac should be opened, disinfected, and drained. Search should be made for the necrosed pancreas, and, when found detached, it should be removed. As in most of these cases the retro-peritoneal tissue is extensively infiltrated, a counter-opening should be made in the lumbar region above or to one side of the kidney, and through drainage established. If an anterior abdominal fistula cannot be established, the course pursued should be the same as in treating a pancreatic abscess under similar conditions.

Abscess of the Pancreas.—At the present time no one familiar with the recent advances in surgery would question the propriety of treating a suppurating cavity by incision and drainage, wherever it might be located. Some of the most valuable recent contributions to surgical literature describe improved methods of treating deep-seated abscesses. Asepsis and effective drainage are the two cardinal points upon which we have learned to depend in the treatment of abscesses in important organs or cavities. If we can secure and maintain these two essential conditions, we can attack, with a fair hope of success, any abscess wherever it may be located, and whatever its immediate surroundings may be.

In looking over the literature on abscess of the abdominal organs, we find that modern surgery has been guided almost exclusively by the teaching of the old master: *ubi pus—ibi evacuo.* It is somewhat surprising, therefore, that abscess of the pancreas has never been made the subject of surgical treatment. The two principal reasons for this may be found in the facts that abscess of the pancreas is of rare occurrence, and that the recognition of the lesion, when it does exist, is surrounded by many difficulties. There can be no doubt, however, that in the near future this affection will be treated on the same principles as suppuration in any other locality.

The remote location of the abscess may offer many serious obstacles to a correct diagnosis and a rational course of treatment; but these difficulties will be overcome by improved methods of examination, and more perfect methods of operation. As suppuration is only one of the terminations of inflammation, abscess, like inflammation, may occur primarily in the gland itself, or it may commence in the para- or peri-pancreatic tissue. If the abscess is endo-pancreatic, it may be bounded and circumscribed by the proper investment of the gland; if, on the other hand, it commences primarily outside of the gland, it appears as a diffuse abscess, which extends to the pancreas by contiguity; in other words, we speak of the abscess as a suppurative pancreatitis, or a suppurative peri- or para-pancreatitis.

Case 1. Frison[30] reports a case of abscess of the pancreas, following suppurative pancreatitis, in which the collection of pus did not extend beyond the limits of the gland. An otherwise healthy mulatto, twenty-eight years of age, farmer, was attacked in June, 1873, by icterus with no fever. Appetite diminished. The symptoms were not of sufficient severity to keep him from his work. In August he complained of pain in the right hypochondriac region, which was soon followed by ascites and œdema of the legs and scrotum. He was troubled at this time by an intense thirst, and voided large quantities of urine, which, on examination, was found to contain sugar. The liver was enlarged and the patient emaciated rapidly. No fever or diarrhœa. Stools clay-colored. The appetite gradually declined, and the patient died in a state of advanced marasmus. At the autopsy the intestines and stomach were found normal. The pancreas was enlarged to three times its normal size, and infiltrated with pus; the splenic end was distended by a large abscess. The gall-bladder and bile-ducts were greatly distended. The liver was olive-green in color and contained three abscesses, but was otherwise healthy in structure.

Remarks.—In this case the symptoms during life pointed to the liver as the seat of the disease. The jaundice was undoubtedly produced by stenosis of the bile-duct, resulting either from a catarrhal inflammation of the duct itself, or from compression of the duct by the inflammatory exudation which attended the acute inflammation of the pancreas. The ascites was more likely the result of an inflammation of the peritoneum overlying the pancreas than of an obstruction to the portal circulation. The suppuration in the pancreas was not attended by an increase of temperature. The diabetes was probably due to the disease of the pancreas, and was not a coincident affection, as a number of cases of diabetes have been reported which occurred in the course of some disease of this organ.

Case 2. Timoteo Riboli[31] reports the case of a woman, aged fifty-seven years, who suffered from impairment of digestion, loss of appetite, emaciation, and attacks of vomiting in the forenoon. The tongue was coated. There was no fever, but night-sweats occurred. Bismuth and magnesia improved the symptoms for a time, but soon the disease became aggravated. Hepatitis was diagnosticated, inasmuch as the patient became icteric and complained of a deeply seated, dull pain in the region of the liver and epigastrium. Among the number of physicians who saw the case in consultation, Tomasini was the only one who believed that the pancreas was the seat of the disease. The patient was emaciated to a skeleton and died of inanition. At the autopsy the pancreas was found distended with pus. The gall-bladder was distended with bile, and the liver was congested. No other pathological conditions were found which might serve to explain the cause of death.

Remarks.—The course of the disease in this case was again afebrile. The symptoms simulated disease of the liver even more closely than in the preceding case, as no mention is made of the presence of sugar in the urine. The suppuration did not extend into the para-pancreatic space.

Case 3. The following case is described by Dr. James Kilgour.[32] The patient was a man, forty-one years of age, who was treated for several years for what was termed bilious dyspepsia. In March, 1850, when first seen by the reporter, he was considerably emaciated and of a melancholic disposition. A prominent symptom was vomiting, especially in the morning, and about two hours after meals. The matter vomited was a sour, viscid fluid, varying in quantity from an ounce to a quart. The skin was dry, and of a yellowish hue. There was no diarrhœa, and the stools contained no bile. The urine, of a specific gravity of 1.022, and normal in quantity, was loaded with urates, and contained some fat. Pulse small, 100. No pain in the abdomen. On the left side, from the border of the stomach to the crest of the ilium, the abdomen was dull on percussion, and on palpation inelastic, nodulated, and of a doughy feel. The area of swelling was not well defined. Neither fluctuation nor pulsation could be felt. During the middle of the month of May the patient complained of chilly sensations, and the area of dulness increased toward the left. Toward the end of the month the chills disappeared and the abdomen became tender and elastic above. During the latter part of July the legs became œdematous, and the patient was somewhat delirious. Toward the close of the disease he was again seized with repeated chills, and died on July 28th. The autopsy revealed the stomach distended with gas; its walls were very thin; the pylorus was indurated and slightly narrowed. The duodenum was softened by inflammation, the portion near the pancreas being converted into a pultaceous mass. Liver normal. Spleen enlarged one-third. Pancreas enlarged to the size of a teacup, its left end being attached to the suprarenal capsule on the same side. On incising the pancreas a milky fluid escaped. The entire gland was converted into a single sac, which contained purulent fluid, with some cheesy particles and fragments of cellular tissue.

Remarks.—In this case the symptoms were sufficiently clear to enable an accurate observer, at the present time, to make a probable diagnosis of abscess of the pancreas. The obstinate vomiting, with the absence of signs of disease of the liver, and the progressive emaciation, should

have led to at least a suspicion of disease of the pancreas.

The location of the tumor was also suggestive of the primary starting point of the swelling. The abscess cavity was larger than in the preceding cases, and the presence of pus was also suggested by the chills which were present at the beginning and close of the disease. As the abscess cavity was single, this would have been a proper case for surgical treatment. A somewhat uncommon feature in this case was almost complete absence of pain, a symptom which has been considered by Claessen characteristic of disease of the pancreas. The character of the fluid in the cyst would indicate that it was a mixture of pus and pancreatic juice. As in other secretory organs, the suppurative process may commence in the duct and extend to the interstitial connective tissue by continuity. This is the manner in which the presence of foreign bodies, such as parasites or calculi in the duct, give rise to abscess of the pancreas. In the following case the inflammation of the duct and the consecutive interstitial suppurative pancreatitis were attributed to the presence of an intestinal worm.

Case 4. (Reported by Shea.[33]) The patient was a woman, aged twenty-nine, who complained of abdominal pain, and was jaundiced. After a few days she improved under a mild alkaline treatment, but about three weeks subsequently again became worse. The pain was in the region of the pancreas. At the same time she suffered from nausea, followed by vomiting, and the jaundice reappeared. Active treatment was resorted to, but she soon became unconscious, and died forty-eight hours subsequently. The necropsy showed that the body was fairly nourished, and distinctly jaundiced. The lungs were slightly congested at the base. Liver large, pale, and soft. Pancreas enlarged and hard, being the seat of an abscess containing pus. A round worm, seven inches long, was found folded upon itself, lying in and obstructing the pancreatic duct, the larger portion of the worm being in the duodenum. The intestines were healthy. In the absence of any other disease, death in this instance must have resulted from inflammation of the duct and parenchyma of the pancreas, by the irritation produced by the presence of the worm. The jaundice was undoubtedly produced by the same cause.

Positive evidence is wanting in this case to prove that the suppuration was caused by the presence of the parasite, as the worm might have entered the pancreatic duct after death. We have evidence that in many cases ascarides have been found in the ductus pancreaticus, without the presence of abscess or even of inflammation. Davaine[34] relates that he has found them present in this locality in four cases, and in none of them had secondary inflammatory changes taken place. Klebs found six worms in one case, four in the head and two in the tail of the pancreas.

Case 5. Mayo refers to a case that came under the observation of Percival.[35] The patient was a gentleman who had jaundice and bilious vomiting. A tumor appeared at the epigastrium; his strength failed; blood and fetid pus were discharged by stool, and he died exhausted in three months. At the necropsy the pancreas was found greatly enlarged, and contained an abscess of considerable size; the ductus communis was obliterated by the pressure.

The cases which are of special importance and interest to the surgeon are those diffuse abscesses which take their origin in the para-pancreatic connective tissue—extensive collections of pus, such as we observe in cases of para-pancreatitis purulenta. As the glandular tissue is not primarily affected in these cases, early evacuation and drainage of the abscess cavity would not only preserve the anatomical and functional integrity of the gland, but would also serve as a life-saving measure by securing an early outlet of the contents of the abscess.

The case reported by Haller and Klob, and referred to under the head of pancreatitis, Case 1, furnishes a good illustration of cases belonging to this class.

Case 6. An interesting case of abscess of the pancreas has recently been reported by Musser.[6] The patient was a male, aged forty-two, shoemaker, who was admitted to the wards of the Presbyterian Hospital on May 12, 1885, and died on June 6th following. He was of intemperate habits, but his general health had always been good. His poverty had exposed him to all kinds of hardships. The duration of the present illness was not known, but from his statements it was ascertained that his health had been failing all the spring. He had never received any injury. He was considerably emaciated. He vomited only once, and that was on the day of his admission. Marked ascites was observed, but nothing else could be found. He remained in a stupid condition, took but little food, and manifested no sign of pain. There was neither fever nor sweating. Palpation showed the liver and spleen to be normal, while an ill-defined tumor could be felt in the epigastric region. The urine contained a trace of albumen, but no casts. The ascites was so great as to warrant tapping, and this was accordingly done. The abdomen was thirty-six inches in circumference at the umbilicus before tapping. Within eighteen hours after tapping it had filled again, and in twenty-four hours measured thirty-two and a half inches. He died of exhaustion.

After death a fixed mass was detected by palpation in the abdomen, extending from the right mammary line, one inch above the umbilical line, directly across to the corresponding line on the left side. Its upper margin was not well defined, but it appeared to be two inches wide. The abdomen was filled with serum in which some lymph floated. The intestines were matted together by recent lymph. The peritoneum showed signs of inflammation. Corresponding to the position of the mass indicated by palpation, the omentum was found matted together, with its inferior border turned upward and lying across the stomach. This organ was fixed and dilated, its inferior border extending to the umbilicus. The liver occupied its normal position. The transverse colon extended across the abdomen along the lower margin of the stomach, thus permitting the cæcum to occupy the position indicated above. Further study of the relations of the abdominal organs revealed the formation of a large cavity containing about a quart of pus. This cavity was formed by the posterior wall of the stomach in front, by the pancreas, duodenum and transverse colon below, and by extension, or rather distention, of the peritoneum above and behind. Certainly the pus did not fill the retro-peritoneal space nor extend into it, and was not in close apposition to the diaphragm or brim of the pelvis. It was situated in the duodeno-jejunal fossa. Adhesions prevented communication with the abdominal cavity and the retro-peritoneal space. This abscess cavity communicated with another abscess, the size of an orange, situated in the head of the pancreas, its point of rupture into the duodeno-jejunal fossa being in the middle and upper part.

The remainder of the pancreas was made up of dense connective tissue, throughout which there were innumerable pus-pockets, varying from a pea to a pecan-nut in size. The secreting tissue of the organ was not discernible to the naked eye. The ducts were not occluded, but rather dilated, and no calculi were found. The portal vein was filled with a purulent thrombus. The splenic vein was also partially closed by a soft thrombus. The superior and inferior mesenteric veins were completely blocked by laminated thrombi, which were firmly adherent to their walls. On microscopical examination the pancreas was found to be made up of old and young connective tissue; in the large interstices of the bundles of old tissue the glandular structure could be readily made out, while the tubes were seen to be in a state of catarrhal inflammation. The intertubular connective tissue was crowded with small cells.

Remarks.—In this case the conditions were favorable for successful treatment by abdominal section, had even a probable diagnosis been made before the extensive and serious complication of thrombo-phlebitis occurred. The symptoms during life simulated cirrhosis of the liver so closely that it was impossible to differentiate between this affection and disease of the pancreas, although an ill-

defined tumor could be felt in the epigastric region. In similar cases an exploratory laparotomy should be done for the purpose of making a positive diagnosis, and, when similar favorable conditions are found, it could be followed at once by radical measures with a view of securing evacuation and drainage of the abscess cavity. In this case the multiple abscesses in the viscus were the result of a purulent pancreatitis; the secondary abscess, of perforation to the duodeno-jejunal fossa followed by suppurative peri-pancreatitis.

Pathology of Abscess of the Pancreas.—Recent investigations have shown the existence of a direct causative relation between the pus microbes and suppuration, hence we must take it for granted that every purulent pancreatitis, peri-pancreatitis, or para-pancreatitis is caused by the presence of these germs in the tissues. In case there is no direct invasion by a loss of continuity of the hollow viscera in the vicinity of the pancreas, and no direct communication with the external air by a penetrating wound, we must assume that the germs reach the gland through the circulation, and find a favorable soil prepared by some antecedent pathological change. Such conditions may be determined by contusion of the organ, disturbance of the capillary circulation from various causes, or by thrombophlebitis. Norman Moore[37] reports the case of a female, twenty-seven years of age, who had died of pyo-phlebitis, in whom, on post-mortem examination, besides the portal, splenic, and azygos minor veins, the pancreatic veins were also blocked by decolorized and adherent thrombi.

In the "Transactions of the Pathological Society" the same author gives an account of two cases of abscess of the pancreas due to plugging of the pancreatic vessels. On page 210 he remarks:

"Pathologically, the case in which thrombosis of the pancreas was found is interesting as indicating how pancreatic abscess is produced. The much commoner condition of the liver in the other cases shows that, had the first patient survived, the thrombosis would certainly have been followed by abscess. Clinically, the value of the case is that it may, in rare cases, help to explain the seat of an obscure abdominal swelling, associated with fever, which has followed a thrombosis, and which physical examination cannot localize in the liver."

Suppuration always begins in the interstitial tissue, either within the gland or in the connective tissue around it. A suppurative inflammation and formation of an abscess are different stages of the same process. Suppuration following peri-pancreatitis commences, in most instances, in the adjacent lymphatics, the pus surrounding the lymph-glands, or forming a small abscess.

In the vicinity of the pancreas these peri-lymphatic abscesses are not infrequently met with as one of the pathological conditions of pyæmia. Thus, an abscess in the pancreas, with perforation in the peritoneal cavity, was examined by Perle.[38] Tulpius saw an abscess of the pancreas as a secondary lesion after an attack of malarial fever. Schmackpfeffer observed the same condition after an operation for strangulated hernia, and Portal after the extirpation of a testicle. But suppuration in the pancreas sometimes takes place as an independent affection, without the presence of an appreciable focus of infection, and in these cases we must assume that the essential and specific noxæ are carried along with the circulating blood, and that localization takes place upon a soil prepared for their reception and growth by previous alteration in texture or circulation. In some instances the process begins upon the outer surface of the gland, the pus separating the gland from its attachments. In the case described by Gendrin the pancreas appeared to have been completely detached, and was lying loose in the abscess cavity.

Many of these para-pancreatitic abscesses do not present well-defined borders; the pus manifests a tendency to burrow in the vicinity of the meso-colon and the retro-peritoneal space, and is apt to perforate into the bursa omentalis, or into some other portion of the peritoneal cavity, or, lastly, finds its way into one of the adjacent hollow organs, as the stomach or intestinal tract. Van Derveren reports the case of a female, fifty-nine years of age, who had suffered for thirty years from attacks of gastralgia. At the necropsy it was ascertained that the indurated pancreas had perforated the posterior wall of the stomach. The opening represented a round ulcer, two and a half inches in diameter, with indurated margins. In this aperture eroded vessels could be seen. The fistulous tract communicated with the pancreatic duct. The stomach and intestines contained blood, but no other evidences of disease could be found In Percival's case the abscess ruptured into the bowel, the stools containing fetid pus and blood. A similar case was observed by Haggarth.[39] The suppurative process, however, may extend in an opposite direction, from the stomach to the pancreas.[40] A communication between the stomach and the pancreas is sometimes established by perforation of a gastric ulcer in this direction. Around the margins of the ulcer, between the stomach and pancreas, adhesions are formed, an occurrence which prevents extravasation of the contents of the stomach into the peritoneal cavity. A number of the terminal openings of the pancreatic ducts have been observed upon the cicatrized surface of a gastric ulcer. In the place of the formation of a permanent pancreatico-gastric fistula, as described by Rokitansky, perforation of the stomach, in close proximity to the pancreas, may give rise to diffuse and rapidly fatal para-pancreatitis or peri-pancreatitis.

The indirect primary cause of a pancreatic abscess may be due to the presence of a calculus in the pancreatic duct. Fournier has recorded a case in which, on post-mortem examination, an enormous abscess was found in the head of the pancreas, which contained numerous calculi. The tumor was sufficiently large to be readily detected in the epigastric region during life.

An abscess of the pancreas may also originate in a pre-existing cyst of the organ. Kilgour's case, detailed above, had undoubtedly such an origin. The abscess cavity was as large as a teacup, and contained a milky fluid and caseous particles, which were undoubtedly a mixture of pus and pancreatic juice. The disease was attended by chills and fever, which indicated that the retention-cyst had become the seat of an acute suppurative inflammation.

As primary, idiopathic, uncomplicated, purulent inflammation of the pancreas is an exceedingly rare affection, it is of great practical importance in the surgical treatment of such cases to determine, if possible, the predisposing cause or causes, and to remove them, or render them inert at the time of operation.

Symptoms and Diagnosis.—The presence of pus within the pancreas, or in its immediate vicinity, is not indicated by any characteristic or positive symptoms. The symptoms always point to the stomach or liver as the seat of the disease. The most prominent and constant symptoms which have been observed are nausea, vomiting of a clear greenish or viscid fluid, thirst, loss of appetite, constipation, progressive emaciation, and distention of the epigastrium.

In almost all cases the patients presented a sallow, cachectic appearance, and were exceedingly anæmic. Ascites and œdema of the lower extremities were present a number of times. In several instances the inflammatory process in the pancreas extended to the bile-duct, or caused stenosis of the duct by compression, conditions which are followed by biliary retention, a symptom which has been usually interpreted as an evidence of primary disease of the liver or bile-ducts. The progressive anæmia and emaciation, in the absence of other tangible lesions, are symptoms which should always direct attention to the pancreas as the seat of the disease.

Fever was seldom a conspicuous, and never a constant, symptom of suppurative pancreatitis. The use of the thermometer in the diagnosis of suppuration in this locality is important, but it furnishes no positive evidence. If the abscess is large, it will be recognized by palpation and deep percussion as a tumor in the epigastric region. In such cases a probable diagnosis may be made by a careful and systematic physical examination, and reasoning by exclusion.

An abscess in the gland is always located in the bursa omentalis, a peri-pancreatitic abscess in the bursa omentalis duodeno-jejunal fossa, or upper portion of the peritoneal cavity, and a para-pancreatitic abscess in the retro-peritoneal space. Inflation of the stomach will often serve a useful purpose in the differential diagnosis of tumors in the epigastric region. In obscure cases manual exploration of the rectum may add important, and sometimes decisive, information.

Age is also an important element to be considered in the diagnosis. Most of the cases of abscess of the pancreas occurred in patients of more than forty years of age, and often in persons of intemperate habits. Puncture with an aseptic capillary needle will demonstrate the presence or absence of pus, but will not add material information in locating with accuracy the abscess cavity.

Finally, in all cases in which a tumor can be felt in the epigastric region, and a probable diagnosis can be made regarding its benign character, an exploratory laparotomy should be resorted to for the purpose of making an accurate anatomical diagnosis.

Prognosis.—The prognosis of abscess of the pancreas is always unfavorable. Death is produced by progressive emaciation and inanition, by septic absorption, or results from secondary lesions in adjacent organs. In acute, diffuse pancreatic abscess, a fatal termination may take place in a few days. One of the great dangers of abscess in this locality is the close proximity of numerous important veins, which become implicated by extension of the suppurative inflammation to their walls, producing a suppurative thrombo-phlebitis, with all its disastrous consequences. Perforation of the abscess into the stomach or intestinal tract is the most favorable spontaneous termination, and has resulted, at least in one instance, in a cure. Perforation of the abscess into the peritoneal cavity would hasten death by inducing a rapidly fatal septic peritonitis.

Treatment.—The remarkable success which has attended the treatment of pelvic and abdominal abscesses by laparotomy, justifies the hope that, in the near future, the same treatment will be extended to abscess of the pancreas. It is true that the difficulties which surround the treatment of abscesses in this region are many, but they are not insurmountable. Multiple abscesses disseminated throughout the entire organ, and especially abscesses in its head, are not amenable to surgical treatment. Circumscribed endo-pancreatitic abscess in the peripheral portion of the body or tail of the pancreas, should be treated by partial excision of the pancreas in all cases in which the isolation of that portion of the organ can be accomplished without inflicting serious injury upon adjacent important organs. When extirpation is impossible, as when the abscess is located in the head of the pancreas, it must be treated by incision and drainage. This is accomplished in the same manner as in the treatment of a pancreatic cyst. In some instances the access to the abscess is rendered difficult by distention of the stomach, the dilated organ overlapping the pancreas. In such cases the stomach must be pushed upward, and subsequent distention guarded against by ordering a carefully regulated diet until the external fistula has been established. The external incision must, in all cases, correspond to the most prominent part of the swelling, as it is of the greatest importance to incise the abscess at a point where the distance between the surface of the abscess and the abdominal wall is the shortest. Incision of the great omentum will be required in all instances.

In making an external fistula in the treatment of a pancreatic abscess it is essential to protect the muscular and connective tissues of the external incision against contact with pus, by lining the margins of the wound with the parietal peritoneum before the serous covering of the anterior wall of the abscess is stitched to the margins of the wound. One of the greatest difficulties that will be encountered in this operation will be the approximation of the peritoneal surface of the abscess with the margins of the wound, on account of the distance between the surface of the abscess and the anterior abdominal wall; this difficulty will decrease in proportion to the prominence of the swelling.

The size of the external incision will exert an important influence in this direction. If the incision is large the margins of the wound can be turned inward, thus facilitating the suturing of the anterior wall of the abscess to the margins of the wound. As a rule, it may be relied upon that the anterior wall of the abscess, covered by peritoneum, is quite thick, so that there is little danger of penetrating the abscess cavity with the needle in suturing. Previous evacuation of the abscess cavity by aspiration would diminish the danger of extravasation of pus through the needle punctures, but would also render approximation difficult by the recession of the abscess wall, and should, therefore, not be resorted to unless the swelling is sufficiently prominent to render this circumstance of little importance.

As the suturing of the two peritoneal surfaces is done for the purpose of preventing, in the first place, extravasation of pus into the peritoneal cavity, and, secondly, for securing permanent adhesions between the abscess wall and the margins of the wound, it is important to apply the sutures closely together, and to grasp the tissues in such a manner that tearing through of the sutures is impossible. As considerable tension may follow, it would be advisable, in this particular instance, to use silk sutures. As in these cases time is an important element, incision and drainage should immediately follow suturing.

The remaining steps of the operation will depend upon circumstances. If the abscess is endo-pancreatic or peri-pancreatic, simple incision, drainage, and disinfection will answer all indications. If, however, the purulent cavity is located behind the peritoneum and occupies the connective-tissue space behind the pancreas, it would appear rational to drain the abscess posteriorly through the lumbar region above, on one side of the kidney, by pushing a long closed forceps in a proper direction through the posterior and lateral wall of the abscess until its point can be felt under the skin externally. A small cut in the skin over its point will enable the operator to push the instrument clear through, and, by dilating its blades, widen the canal sufficiently to permit the insertion of a large drainage-tube. In this manner the most desirable method of drainage—through drainage—could be established, which would render subsequent disinfection and evacuation of the abscess a comparatively easy task. In cases in which an anterior pancreatic fistula cannot be established on account of the distance between the abscess and the anterior abdominal wall, we might resort to lumbar drainage and closure of the incision in the anterior wall of the abscess by carefully inverting and approximating the peritoneum over the wound with fine silk sutures.

That the utmost care in the observance of antiseptic precautions should be resorted to in the evacuation of pus in this remote region by any of these procedures requires no argument. I will repeat that a positive diagnosis of the presence and of the precise location of a pancreatic abscess is only possible by resorting to exploratory laparotomy, and that this diagnostic aid should always be invoked when the history of the case, and symptoms and signs presented are sufficiently suggestive to point to a probable diagnosis.

The abscess found and located by abdominal section should be removed by partial extirpation of the pancreas when it is endo-pancreatic and located near the splenic end of the pancreas. When extirpation is impossible or when it is located in the head or on the anterior surface of the pancreas, it should be treated by the formation of an anterior abdominal fistula; when located behind the pancreas, by through drainage, or lumbar drainage established by an operation performed through the abdominal cavity.

Hemorrhage of the Pancreas.—A number of post-mortem examinations have shown that certain cases of sudden death were caused by hæmorrhage of the pancreas, inasmuch as no other evidences were found which could explain the cause of death. In some as yet unaccountable way, even a moderate hæmorrhage in this locality has been sufficient to destroy life. Zenker has affirmed that in these cases pressure upon the solar plexus

and semilunar ganglion produces paralysis of the heart, which he regards as the immediate cause of death. If we recollect that tumors of the pancreas, even when of considerable size, do not destroy life in this manner, it seems that the true explanation of the great danger which attends hæmorrhage of the pancreas remains to be ascertained. Practically, it is important to differentiate between diffuse hæmorrhage into the substance of the organ and its adjacent tissue, and circumscribed accumulations of blood or hæmorrhagic cysts of the pancreas, as the latter condition presents more favorable indications for surgical treatment.

1. *Hæmorrhagic Cysts.*—Case I. Anger[41] reports a case of hæmorrhagic cyst of the pancreas in a man, seventy-two years of age, who had been a soldier for ten years, during which time he had received several wounds. Later he suffered fracture of several ribs on the left side from a severe contusion, from which injury, however, he recovered completely after three months' treatment in the hospital. No history of syphilis. Five months before admission to hospital the lower limbs became œdematous, and for the six weeks preceding ascites was present. He was admitted into the Beaujon Hospital February 27, 1865. At this time the following conditions were noted: Œdema of the lower extremities; ascites; difficult and stertorous breathing; bronchitis on the left side of chest, and hydrothorax on the opposite side; the diaphragm was pushed upward; pulse 100, irregular and intermittent; diarrhœa and loss of appetite; no delirium; the urine contained no albumen; a stimulating treatment was adopted. March 1st the patient died, the pulse having been for a time exceedingly feeble and intermittent. The breathing toward the last was very labored and the patient was unable to lie down.

Autopsy: Pleuritic effusion on the left side, and bronchitis. Liver small, somewhat contracted, but not cirrhotic. Serous effusion in pericardium; heart dilated, mitral valve insufficient. On opening the abdomen a tumor, the size of a fœtal head, was found in front of, and on a level with, the left kidney. This tumor was bounded in front by the stomach and the transverse colon, above by the diaphragm, below by the descending colon, behind by the kidney, toward the median line by the pancreas, and on the outside and above by the spleen. It was loosely connected with the kidney and spleen by connective tissue, in which the vessels of these organs could be readily seen. The tumor was evidently connected with the pancreas. The external surface was irregular and nodulated, the anterior wall of variable thickness. Fluctuation was distinct. The vessels of the spleen were intimately connected with the posterior surface and were not easily isolated. On careful dissection the lobules of the pancreas could be separated from the tumor, but the walls of the cyst contained a tissue which resembled glandular structure. On opening the cyst a considerable quantity of dark fluid escaped, which contained a number of small, recent coagula. The inner surface of the cyst was uneven and reticulated, resembling in appearance the interior of the right ventricle. On the surface of the prominences, diverticula could be seen, which were in free communication with the principal cyst. The wall of the cyst was very much indurated and thickened at four or five places. Some of these nodules were fibro-cartilaginous in structure, while others had undergone calcification.

Sections of the cyst wall showed under the microscope nucleated epithelial cells which resembled in structure the epithelial cells in the pancreas. Acinous groups of glandular tissue were also found. The reticulated structure in the interior of the cyst contained vessels and remnants of the acini. The author came to the final conclusion that the tumor was a cyst, located in the tail of the pancreas. The presence of blood in the cyst was explained by the supposition that, during the progressive dilatation of the cyst, some of the vessels in the connective-tissue reticulum had ruptured. M. Le Dentu, who examined the cyst, also came to the conclusion that the bleeding had taken place into a pre-existing cyst. What symptoms the presence of the tumor had produced during life could not be ascertained, as the patient was being treated for organic disease of the heart, and the tumor had not been recognized.

Case 2. Störck[42] observed the following case: The patient, a woman, was attacked during the menstrual period by vomiting, which was followed by coldness of the extremities, palpitation of the heart, and dyspnœa. Soon after this time a pulsating tumor was detected in the epigastric region, which caused considerable pain. The patient also suffered from constipation and attacks of vomiting. She died three and a half months after the first attack. At the autopsy the entire pancreas was found enormously dilated, and weighed with its contents thirteen and a half pounds. On cutting into it, it was found filled with coagulated blood. Judging from the condition of the coagula, bleeding had occurred at intervals. The weight of the tumor had caused injurious pressure upon adjacent organs. Le Dentu believed that the hæmorrhage was caused by the act of vomiting, and had taken place into a pre-existing cyst of the pancreas.

Case 3. John Parsons[43] reports a case where hæmorrhage into a pre-existing cyst proved fatal after the latter had ruptured into the intestinal tract. The patient was a woman, sixty years of age, who had suffered from vague dyspeptic symptoms for an indefinite length of time. When she was examined by the reporter a fluctuating tumor the size of an orange could be felt in the epigastrium, just below the greater curvature of the stomach. Emaciation progressed rapidly. The tumor disappeared suddenly, and at the same time a viscid, dirty white fluid was discharged through the bowels. The tumor reappeared in a short time, and ruptured a second time into the intestines, and this was followed by hæmorrhage into the ruptured cyst which proved fatal. At the autopsy, the pancreas was found excavated into a wide canal, which, at either extremity, was dilated into a cyst. The walls of the cyst were of the firmness of cartilage, and the organ was adherent to the stomach, kidney, and colon. Coagulated blood was found in the dilated duct and cysts.

Remarks.—In Anger's case there is room for speculation concerning the origin of the cyst and the source of hæmorrhage. As the cyst had not ruptured and did not remain in communication with the patent pancreatic duct on the proximal side, we can only explain the absence of any contents in it previous to the occurrence of hæmorrhage, by assuming that absorption took place as hæmorrhage increased, if we adopt the idea that the bleeding occurred into a cyst which had been formed before hæmorrhage took place.

Two other explanations might be offered. First, that the parenchymatous hæmorrhage produced the cyst, the circumscribed coagulum separating the interstitial tissue, and that this space became lined with endothelial cells developed from the connective-tissue cells, subsequent hæmorrhage occurring from the interior of the cyst wall. Again, the hæmorrhagic cyst might have originated in a dilatation of one of the vessels of the pancreas, a varicose ectasia of the vessel.

In the second case, it appears more than probable that hæmorrhage occurred by rupture of a vessel and extravasation of blood into the altered parenchyma of the gland, distending the entire capsule of the organ—in other words, the condition was a hæmatoma of the pancreas. In Parsons' case the clinical history and the post-mortem appearances prove beyond all doubt that the fatal hæmorrhage took place into a pre-existing pancreatic cyst. The immediate cause of the hæmorrhage in this case was undoubtedly the inflammatory changes in the interior of the cyst following the first rupture, and sudden diminution of intra-cystic pressure after the second rupture.

2. *Diffuse Hæmorrhage.*—Case 1. (Reported by H. Hudson Rugg.[44]) A man, aged forty-two, had just recovered from an attack of acute articular rheumatism, when he was attacked suddenly with a severe pain in the left lumbar region. He fell almost instantly into a collapse. This was followed by cold, clammy sweat, and other symptoms of acute anæmia. He never rallied, and died within a few hours. On opening the abdomen after

death a large quantity of recently extravasated blood was found between the pancreas and left kidney. A careful search for the source of the hæmorrhage was made, when it was found that the blood had escaped through an opening of considerable size, which presented the appearance of an ulcer on the anterior surface of the pancreas, and which contained a blood-clot the size of a walnut. Sections through the pancreas showed a number of small excavations filled with blood, the size of a hazel-nut and smaller, which looked like aneurismal dilatations.

Case 2. (Reported by Oppolzer.[45]) The patient suffered from severe pain in the epigastric region, followed by vomiting, which always aggravated the suffering. The vomited matter consisted of mucus and bile. The disease was attended by fever, very frequent pulse, and cold extremities. The bowels were constipated. No blood was vomited, and the case was diagnosticated as perforating ulcer of the posterior wall of the stomach. On the third day after admission to the hospital the patient died. At the autopsy the stomach was found in a healthy condition, but in the pancreas and between the layers of the mesentery a copious effusion of blood was found. The pancreas was the source of the hæmorrhage. This organ was enlarged to double its normal size, was of a dark red color, and on section was found infiltrated with a blood-stained exudation between the acini.

Case 3. (Reported by Hilty.[46]) The patient was a mechanic, aged thirty ; tall, stout, and muscular, but of intemperate habits. One evening he drank beer to excess, and on the following morning, without any premonitory symptoms, he was seized suddenly with a painful tension of the abdomen, which gradually increased in intensity. He was sent to the hospital, where, on examination, he was found in a collapsed condition. The extremities were cold, and the forehead was covered with a cold, clammy perspiration. All the symptoms indicated acute anæmia. On physical examination nothing abnormal was found, except that the upper part of the abdomen was distended and painful, especially on pressure. Diagnosis of poisoning or gastritis was made and treatment adopted in accordance with this view. The patient never rallied, and died in the evening of the following day. At the necropsy the omentum and mesentery were found loaded with fat. There was no abdominal effusion and no trace of peritonitis was discoverable. The diaphragm was pushed upward as high as the fourth rib. In the connective tissue around the pancreas a copious effusion of blood was found. The pancreas was double its normal size, firm in structure, and of a dark violet color. On section, the lobules were seen to be of a dark color, and the interlobular tissue was infiltrated with blood ; this infiltration was most copious in the head of the organ. The duct of the gland was normal, but the vein running along the lower border of the pancreas was distended with blood-clots. No other pathological conditions were found which could explain the sudden death.

Case 4. (Described by Portal.[47]) This is the first case of the kind on record. A merchant had suffered for two years from colicky pain in the abdomen, nausea, and diarrhœa ; emaciation appeared early and continued progressively. Twenty days before his death fever made its appearance. The pancreas presented a violet color, was softened, and from its whole surface exuded a black, offensive fluid. The stomach and duodenum showed evidences of inflammation at some points adjacent to the pancreas.

Case 5. (Reported by Haller and Klob.[48]) The patient was a man, sixty six years of age, who had died after a short illness. The pancreas was found almost completely detached, its only connection with the adjacent organs being a few strings of connective tissue. It was surrounded by a serous fluid. The stomach was perforated from without, the cells of the pancreas were disintegrated, granular, and changed into detritus, and the splenic vein was filled with a thrombus.

Kollman[49] reports two cases of hæmorrhage of the pancreas, the first of which came under his own observation, and the second under the care of Gerhard.

Case 6. Female, suffering from stenosis of mitral valve and pleuritis on left side. One afternoon, after having partaken of a liberal dinner, she had an attack of diarrhœa, but no vomiting. During the night she had a chill and an anxious sensation with jactitations. In the morning of the following day she felt greatly improved, but soon after expired suddenly. At the autopsy there was found subperitoneal extravasation of blood at the pyloric end of the stomach. The mucous membrane of the duodenum along the convex side was infiltrated with blood, but intact. The pancreas was hyperæmic and surrounded with an extravasation of blood, which was most marked in the retro-peritoneal connective tissue, extending to the hilus of the spleen. The tail of the pancreas was more hyperæmic than the remaining portion of the gland, and was infiltrated with blood.

Case 7. The patient was a female, who, from the symptoms presented, was supposed to suffer from bronchial catarrh, emphysema, ascites, and anasarca. She was suddenly seized with collapse, and died in a few hours. At the necropsy the subperitoneal tissue of the duodenal peritoneum was suffused with blood. There was considerable hæmorrhage into the pancreas, and the retro-peritoneal space behind the pancreas was distended with blood.

Remarks.—A careful perusal of the above cases must satisfy the most casual observer that the hæmorrhage was produced by different causes, and constituted simply an expression of different pathological conditions. In the material presented, three distinct, primary, pathological conditions will be recognized : 1, Disease of the blood-vessels of the pancreas ; 2, chronic parenchymatous degeneration of the gland ; 3, acute hæmorrhagic pancreatitis.

In Rugg's case the patient had just passed through the stages of acute articular rheumatism, and had not suffered from symptoms referable to organic disease of the pancreas, when he died suddenly from internal hæmorrhage, which was traced to the pancreas. The pancreas itself showed no other pathological changes, except circumscribed cavities filled with blood, which are referred to as resembling aneurismal sacs.

Case 3, reported by Hilty, is an illustration of the second class. Extensive fatty degeneration was found to exist in the tissues generally. Klob found interstitial inflammation of the pancreas as a result of prolonged congestion of the portal vein. Zenker reported three cases which he had observed in the course of one year, to the Naturforcher Verein at the Breslau meeting in 1875. In all, the amount of blood extravasated was slight. His observations on hæmorrhagic infiltration of the pancreas as a cause of sudden death are of great importance to the medical and legal profession. Death from this cause takes place more frequently than is generally supposed.

The facts observed by Zenker were nearly the same in all cases. A corpulent subject died suddenly, or was found dead. Post-mortem examination revealed, as the only tangible pathological change, hæmorrhagic infiltration of the pancreas and neighboring connective tissue, and advanced fatty degeneration of the pancreas.

Further, there was found in two cases bloody effusion of the duodenum, and in two others excessive engorgement of the semilunar ganglion. Zenker believes that paralysis of the heart, whether directly or indirectly caused, must be regarded as the immediate cause of death in these cases. Diffuse infiltration is more common than circumscribed, showing that the same cause exists throughout the entire gland. The bloody effusion is usually not limited to the capsule of the gland, but infiltrates the adjacent spaces, more especially the retro-peritoneal connective tissue. The gland is softened, the anterior serous covering disorganized, and the extravasated blood escapes into the bursa omentalis. These conditions are followed rapidly by death, so that even the peritoneum does not show any secondary changes.

In the last class of cases, where the hæmorrhage occurs as a symptom of a peculiar and exceedingly malignant form of inflammation of the pancreas, we have reason to believe that the inflammation is due to the presence

of a specific form of infection. Klebs believes that in these cases the corroding qualities of the pancreatic secretion may induce the destructive process. Reasoning from analogy, it is, however, probable that the immediate and essential cause is to be found in some form of microbic infection.

The last two cases show that prolonged congestion of the abdominal organs, from obstruction to the return of venous blood, may act as an exciting cause in producing parenchymatous hæmorrhage into the pancreas altered by antecedent pathological conditions.

Symptoms and Diagnosis of Hæmorrhage of the Pancreas.—The premonitory symptoms which precede the hæmorrhage are referable to the particular kind of tissue changes in the pancreas which predispose to rupture of the blood-vessels. In all instances of pathological hæmorrhage we have the usual train of symptoms which point to the textural changes in the pancreas as the seat of lesion. Loss of appetite, nausea, vomiting, epigastric pain, constipation, and debility are the most prominent symptoms in cases of degeneration of the pancreas. When the hæmorrhage takes place in the course of an infective, hæmorrhagic pancreatitis, we have a complexus of symptoms indicating the presence of an acute inflammation of the organ, usually attended by a rise in temperature. In some cases the hæmorrhage produces death so rapidly, and the symptoms which attend this occurrence are of such short duration, that it has been impossible to determine them by actual observation. When the patient dies from loss of blood, the accident is announced by the well-marked symptoms indicative of external hæmorrhage: a sharp pain in the region of the pancreas, followed almost immediately by collapse, cold extremities, absence of pulse, cold, clammy perspiration, and a speedy death. If hæmorrhage takes place into a pre-existing cyst, the presence of which has been previously determined, the accident may be suspected if pain is suddenly increased, if the tumor becomes larger and more tense, and more particularly if the patient's condition indicates a sudden increase of anæmia. Physical examination can be of value only if hæmorrhage occurs into a pre-existing cyst of considerable size, or if the effusion of blood is sufficiently copious to give rise to an appreciable swelling in the immediate vicinity of the pancreas.

Treatment.—The propriety of surgical treatment of pathological hæmorrhage of the pancreas can only be entertained when the accident takes place in consequence of circumscribed, benign, pathological conditions, which in themselves do not jeopardize the life of the patient, and which admit of measures for arresting hæmorrhage by direct treatment. Operative interference should, therefore, be limited to the class of cases described under the head of Hæmorrhagic Cysts of the Pancreas. In well-defined cases belonging to this group it would be justifiable to resort to abdominal section as the only means of arresting fatal hæmorrhage, by direct ligation of the bleeding points, or by removing the localized portions of diseased tissue from which the hæmorrhage had taken place.

For instance, in Case 1, partial excision of the pancreas in which an ectatic vessel had ruptured would have definitely arrested the hæmorrhage without interfering with the physiological function of the remaining portion of the gland. When profuse hæmorrhage takes place into a pre-existing cyst of the pancreas, further hæmorrhage can be effectually arrested by establishing an external pancreatic fistula of large size, plugging the interior of the cyst with iodoform cotton, and applying firm elastic compression of the abdomen with a rubber webbing bandage over the antiseptic dressing. If this procedure should fail to arrest the hæmorrhage, the abdominal incision should be enlarged and an attempt made to extirpate the cyst, with or without resection of that portion of the pancreas from which it has grown, according to the size or location of the cyst.

In diffuse hæmorrhage of the pancreas, due to localized lesion, the same treatment is applicable as advised in the treatment of hæmorrhagic cysts of the pancreas.

Cysts of the Pancreas.—In the preparation of this article it has been my intention to present a full report of a case of retention-cyst of the pancreas which has recently come under my observation, and at the same time give in brief the clinical history of similar cases, which will serve as a basis for some general remarks on the surgical treatment of cysts of the pancreas.

Case 1.[50] Volz, aged nineteen, laborer, German, was admitted into the Milwaukee Hospital November 28, 1884. He was small for his age and not robust, but he claims that, with but one exception, he has never been sick, and that no hereditary tendency to disease exists in his family. Five weeks ago, while enjoying perfect health, he was thrown from a wagon, striking the ground on the left side of the abdomen, a heavy keg falling upon his back and increasing the force of the fall. The pain felt immediately after the accident was confined to his back, at a point where he was struck by the keg, but it was not sufficient in intensity to prevent him from following his occupation as a mason's apprentice. In a few days, however, diarrhœa set in, which persisted for two weeks, greatly reducing his strength and weight. If he had any fever during this time it was not sufficiently intense to attract his attention. His appetite was not impaired, and, although he vomited occasionally, neither vomiting nor the diarrhœa seemed to be aggravated by the time of eating or by the kind or variety of food. After two weeks he noticed a tumor in the left hypochondriac region which was round, smooth, and painless. The tumor increased rapidly in size, and soon gave rise to a sensation of fulness in the stomach, and later on to regurgitation and vomiting soon after meals. The appetite was slightly impaired. At this time the patient was treated for a short time by my friend, Dr. F. H. Day, of Wauwatosa, Wis., who resorted to symptomatic treatment, and, observing no improvement, referred him to me for diagnosis, and, in case it should be deemed advisable, for surgical treatment. On his admission into the hospital he presented a considerable degree of emaciation, and complained principally of a sensation of fulness and weight in the region of the stomach, which was always aggravated after meals and only relieved by vomiting. On inspection a tumor was found, which occupied nearly the whole epigastric and the entire left hypochondriac region, its most prominent point being to the left of the median line, and about three inches below the xyphoid cartilage (see Fig. 2749). Percussion revealed a line of dulness extending from the left nipple to within an inch above the umbilicus; posteriorly the dulness reached from the eighth to the lower margin of the twelfth rib; in the epigastric region a limited area of tympanitic resonance was discovered along the costal arch of the lower ribs on the right side. Palpation showed distinct fluctuation, the wave being conveyed from side to side across the whole area of dulness. The tumor was round in contour and presented a smooth surface. The measurements were as follows: From the left nipple to the lowest point downward twenty-two centimetres, the transverse diameter twenty-one centimetres, and the anterior circumference sixty-three centimetres. The heart was pushed upward so that the impulse of the apex could be distinctly felt in the fourth intercostal space. The stomach was artificially distended with carbonic acid gas, when it was ascertained that it was pushed to the right and compressed by the tumor.

The liver appeared to be unaffected by the tumor, as on percussion it was found in its normal location and of natural size. Both lumbar regions were tympanitic, and there was no evidence of ascites. Firm pressure over any part of the tumor could be made without causing pain. The peculiar fremitus often felt in cases of echinococcus cysts was absent. No pulsations could be felt in the tumor, and no impulse was imparted to it by the underlying abdominal aorta. The relative position of the tumor was changed during forcible inspiration and expiration. For the purpose of ascertaining the nature of the contents of the tumor, a hypodermic needle was thoroughly disinfected and introduced at a point where the tumor was most prominent; when it was in place the distal end of

the syringe moved upward and downward synchronously with the respiratory movements, showing that the adhesions with the parietal peritoneum, if any existed, were slight. The fluid which was removed was somewhat viscid and slightly opalescent. It was alkaline in reaction, and contained a considerable proportion of albumen, as it coagulated on applying heat and nitric acid. Under the microscope it showed only a few morphological elements, epithelial cells, a few leucocytes, granular matter, and no hooklets nor cholesterine crystals.

By exclusion the diagnosis was narrowed down to one of two things: a sterile echinococcus cyst or a cyst of the pancreas. Against the former spoke the rapid growth of the tumor, its primary origin away from the liver (the favorite location of such tumors), the presence of a considerable amount of albumen, and the absence of hooklets, the presence of which are diagnostic of echinococcus cysts. In favor of a pancreatic cyst spoke the following: The history of traumatism in the region of the pancreas, the rapid growth of the tumor, and the early disturbance of digestion, as manifested by diarrhœa and vomiting, presumably caused by the partial or complete retention of the pancreatic secretion. As the treatment remained the same in either case, it was decided to perform laparotomy and

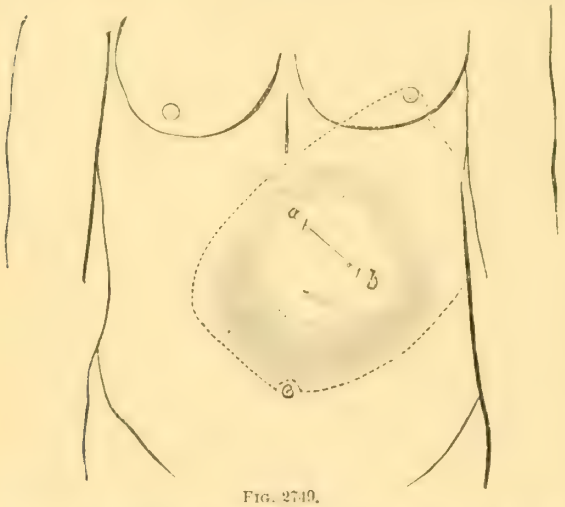

Fig. 2749.

stitch the cyst-walls to the peritoneal covering of the wound in the absence of adhesions, and to open and drain the cyst after adhesions had formed. This procedure was deemed preferable to the use of the trocar or aspirator, as it would with certainty prevent extravasation of the contents of the cyst into the peritoneal cavity, and the drainage-tube would guard against reaccumulation of the fluid, thus affording an opportunity for the cavity to undergo obliteration by adhesion of the inner surfaces of the cyst-walls. The patient, being cognizant of the fact that no other form of treatment would promise any relief, readily assented to the operation proposed. Every precaution was observed to render the operation aseptic. The patient was made to take several baths, the parts were shaved and carefully disinfected with a five per cent. solution of carbolic acid, the instruments, sponges, and operating room being prepared the same as for ovariotomy. Before ether was administered, the stomach was emptied and washed out by means of an elastic stomach-tube, with a view to prevent retching and vomiting during and after the operation. An incision *a*, *b*, Fig. 2749, five inches in length, was made obliquely over the most prominent portion of the tumor, about three inches below and parallel with the left costal arch. A portion of the rectus abdominis muscle was divided. After dividing carefully the tissues down to the peritoneum, all hæmorrhage was carefully and completely arrested.

On opening the peritoneal cavity, the omentum was brought into view, the portion exposed containing an artery and a vein of considerable size. As these vessels were placed in a vertical direction, they crossed the wound, and it became necessary to apply a double ligature, the omentum being then incised between them to the extent of about three inches. The omentum was slightly adherent to the parietal peritoneum and to the surface of the tumor. Through the omental incision the tumor could be distinctly seen and felt, presenting a smooth, whitish, and glistening surface. As it had formed at least slight adhesions, it was decided to complete the operation. This plan was the more willingly adopted, as it was evident that the intra-cystic pressure was great, and the cyst-walls thin—which would render stitching them to the margins of the wound difficult and unsafe. The surface of the tumor was then seized with two dissecting forceps about an inch apart, and gentle traction was made during incision and evacuation of the cyst, so as to prevent all risk of extravasation of fluid into the peritoneal cavity. The peritoneal covering was picked up and nipped, and a grooved director was inserted into the opening made. Owing to the thinness of the walls of the sac it penetrated the interior, and fluid escaped along the groove with considerable force. The opening was enlarged with the knife, when the fluid gushed out in jets and was caught in basins. The contents were removed as completely as possible by making external pressure, and by placing the patient upon his left side. As the cyst was emptied, its walls were drawn forward into the wound and stitched to the peritoneum, which had been previously united with the skin. The interior of the cyst was explored by inserting the index-finger, which passed directly backward toward the tail of the pancreas. The bottom of the cavity could, however, not be reached. The inner surface of the cyst was smooth. Two large drainage-tubes were inserted to the bottom of the cyst, and the remaining portion of the wound was united in a similar manner as after ovariotomy, only that the rectus muscle was sutured separately. The quantity of fluid removed was estimated at three quarts, and presented the same appearance as that which was removed by exploratory puncture. The wound was dressed with a large antiseptic compress, which was retained *in situ* with an elastic rubber bandage. This bandage, made of rubber webbing, not only retained the dressing perfectly, allowing at the same time the movements of the chest and abdomen, but had an additional advantage, inasmuch as it exerted equable pressure, an important element in the after-treatment of all abdominal operations.

The patient never vomited during or after the operation, and experienced immediate relief after the removal of the pressure which was caused by the tumor. The pulse never rose above 99 after the second day; the highest temperature observed was 100° F., the day after the operation. The appetite increased, and no unpleasant subjective symptoms were complained of at any time. On the third day the dressing showed moisture on the external surface, and it was changed. The gauze was saturated with the secretions from the cyst. The wound looked healthy, but the surrounding skin, as far as the dressing had extended, was red and macerated, and the epidermis could be removed in large flakes, leaving a raw surface beneath. The changes in the skin presented the same appearance as those described by Kulenkampff and Gussenbauer, and claimed by them to be due to the digestive power of the pancreatic juice. The excoriated surface was sprinkled with salicylic acid, and was again covered with a Lister dressing. On account of profuse secretion from the cyst the dressings were changed every few days, and at every change the skin was found excoriated as far as it had been moistened by the secretion. At the end of the first week the sutures were removed and no further dressings were applied, whereupon the skin healed without suppuration, and only a minimum amount of pus escaped through the fistulous opening with the secretion. The secretion became clearer after the operation, and continued to discharge in varying quantities for almost four weeks. One of the drainage-tubes inserted at the time of the operation was removed at the first change of the dressing, and the second was

gradually shortened, and entirely removed three weeks after the operation. At the end of the second week, the cyst was explored with a disinfected probe, which passed to a depth of eight inches in the direction of the tail of the pancreas. The fistulous tract soon became lined with granulations, and grew smaller in length and diameter until, at the end of eight weeks, it was so narrow as to admit only a small probe, which could be passed to a depth of but four inches. The skin around the fistulous opening had been drawn inward, forming a deep, funnel-shaped depression.

On January 22, 1885, the patient was discharged cured. The fistula had completely closed. Retraction of the cicatrix was very marked. The general health was good, and digestion perfect. No swelling could be felt in the region of the pancreas.

Remarks.—The clinical history is somewhat similar to that of analogous cases which will be referred to in this paper. It was my intention to collect some of the secretion for the purpose of ascertaining its digestive properties on different articles of food, but before this could be done the amount secreted daily became so small that it was impossible to obtain corroborative diagnostic evidence from this source. The anatomical location of the tumor, its relations to the surrounding organs, its rapid growth, and the character of its contents, can leave no possible doubt that we had to deal with a genuine retention-cyst of the pancreas. The question naturally arises, what was the cause of the obstruction? The history of the case points clearly to traumatism as the exciting cause. The patient had been in good health until he received the injury, and since that time he had not been well, although he continued at his work for some time afterward. Whether the diarrhœa from which he suffered for the first two weeks resulted from injury to the pancreas, we are unable to prove, but it may be possible that a retention of the pancreatic secretion occurred after the traumatism, and that diarrhœa may have been produced by the absence of the fluid in the intestinal tract. As the patient at this time was not under medical observation, the character of the stools was not ascertained. As the injury was inflicted in the region of the pancreas, it is reasonable to assume that the pancreatic duct and the parenchyma of the gland were lacerated at a certain point, producing obstruction to the outflow of the secretion from the distal portion of the organ, the nature of the injury and the manner of obstruction being the same as in cases of rupture of the male urethra. It would be difficult to imagine that the common duct could be distended by the accumulation of the retained fluid to such an enormous extent in such a remarkably short time, hence we are forced to conclude that laceration of the duct took place, that the pancreatic fluid infiltrated the gland, and that the cyst formed at the expense of its parenchyma and by distention of the capsule of the organ. The cyst-wall anteriorly was so thin that after cutting the peritoneal covering the grooved director penetrated directly into the interior of the cyst, without using more than the slightest force, which would show that nothing but a little connective tissue was interposed between the peritoneum and the cyst-contents. The rapid growth of the cyst would indicate that the obstruction occurred at some distance from the caudal extremity of the gland, thus making a considerable portion of the secreting tissue contributory to the formation of the cyst. The early cessation of the discharge of the secretion through the abnormal outlet would tend to prove, either that after the removal of the intra-cystic pressure the duct again became permeable, and thus furnished a free passage to the secretions into the intestinal canal through the natural channel, or that the gland-tissue in the vicinity and distal to the cyst had been destroyed. In regard to the operation, it is necessary to say that I deviated from the usual plan in not making the incision through the linea alba. The incision was made over the most prominent part of the tumor, for the following substantial reasons:

1. If adhesions had formed, they would naturally begin at a point where the tumor impinged most firmly against the anterior abdominal wall.

2. Incision over the most prominent portion of the cyst would afford the best point for effective drainage.

The band of connective tissue which would result from atrophy and obliteration of the cyst would form a permanent bridge between the cicatrix of the abdominal wound and the gland, consequently it was advisable to establish this necessary evil where it would do the least harm by interference with the functions of important organs.

Aspiration of the cyst was not practised, because the exploratory puncture had demonstrated that firm adhesions had not taken place, and in the absence of these it was feared that some of the cyst-contents might escape into the peritoneal cavity and produce peritonitis. The maceration of the skin was the result of the digestive action of the pancreatic juice, and this phenomenon furnished strongly corroborative diagnostic evidence in this as well as in previous cases.

The literature on the subject of cysts of the pancreas is extremely meagre, and after diligent search I have only been able to find an account of the following cases, of which I will give a brief report:

Case 2. (Kulenkampff's case.[51]) E., male, thirty-nine years of age, laborer, otherwise healthy, received a number of heavy blows on the abdomen on March 22, 1881. The blows were received, the patient believes, about the umbilicus and in a direction from below upward. When examined a few hours later, no external signs of contusion could be seen, although he complained of intense pain in the upper abdominal and right hypochondriac regions. There was great tenderness on pressure. On the right side posteriorly, above the diaphragm, dulness was detected over an area three inches in height. As the patient complained of lancinating pains in the same locality, and respiration was difficult, the attending physician was induced to diagnosticate traumatic pleurisy. In a few days the febrile symptoms and pain subsided, and in three weeks the patient seemed to be convalescent. Occasional attacks of pain in the hepatic and epigastric regions remained, as did also tenderness on pressure. Physical examination at this time yielded only a negative result. Toward the latter part of May, a swelling made its appearance which seemed to take its origin from the liver. This swelling increased in size until September, when the following conditions were noted: In the epigastric region a round, tense, non-fluctuating tumor could be felt, of the size of a double fist. The larger part of the swelling was located on the right side of the mesial line. Its lower margin extended to within an inch and a half of the umbilicus. Percussion dulness was continuous with the liver, giving the impression as though the tumor sprang from the left lobe of this organ. The tumor ascended and descended during respiratory movements, and there was pulsation in an anterior direction, but no bruit. Palpation was unsatisfactory on account of the contraction of the recti muscles. The appetite and digestion were not impaired. The temperature was normal and there was no icterus. Examination of the urine and stools furnished no clue to the diagnosis.

As from the existing signs and symptoms no diagnosis could be made, it was decided to render the tumor more accessible by dividing the tissues down to the peritoneum. On September 14th an incision was made through the linea alba down to the peritoneum. To the touch the tumor, which moved freely, imparted the sensation of a tense, nodular liver, as in cirrhosis of this organ. The trocar of an aspirator was now introduced toward the right of the mesial line, and after penetrating through dense tissue the distance of a centimetre (one-third of an inch), a cavity was reached, from which about a quart of clear fluid was evacuated. The peritoneal cavity was not opened and the wound was packed with gauze, over which an antiseptic dressing was applied. The diagnosis of an echinococcus cyst, which had already been entertained, was strengthened by this examination. The fluid removed coagulated on applying the tests for albumen, and also spontaneously on standing for some time. It contained no succinic acid. In the deposit, which was very scanty, blood- and lymph-corpuscles were discovered. On September 20th, the peritoneum was incised and

stitched to the skin. The finger which was introduced into the peritoneal cavity came in contact with a freely movable and nodular tumor, which was supposed to be attached to the liver. Its size was fully as large as before the last operation. The incision was again filled with gauze, and four days later adhesions having taken place, the tumor was incised, and about a quart of the same kind of fluid escaped through the wound. On digital exploration it was ascertained that the inner surface of the cyst was lined with mucous membrane, which was studded with polypoid growths. A large drainage-tube was inserted and a Lister dressing applied. During the next two weeks there was no febrile reaction, the tumor disappeared, and large quantities of the same clear fluid escaped through the fistulous opening. On October 10th the secretion had diminished greatly, and the tract had been reduced to the size of an ordinary lead-pencil. Injections of iodine were made with a view to hasten the obliteration of the cyst, but this procedure excited pain, emesis, and renewed secretion of fluid, of which from one-fourth to three-fourths of a quart were evacuated during twenty-four hours. Cauterization with nitrate of silver produced no better result. The skin remained in a state of maceration wherever it was moistened by the secretion, in spite of often repeated changes of dressings. This peculiar condition of the skin first aroused the suspicion in Kulenkampff's mind that he was dealing with a fistula of the pancreas. He therefore collected some of the fluid and handed it to a chemist for analysis. The fluid was almost clear, colorless, frothing upon being shaken, slightly alkaline in reaction. It contained but few inorganic salts, and coagulated on applying heat and nitric acid. It contained no succinic acid. Experiments were made to ascertain its effects on coagulated albumen, neutral fats, and starch, the substances being kept at a temperature of 20° to 25° C. (68° to 77° F.). Special care was taken to preserve its alkaline reaction. A fresh paste, made of four parts of wheaten flour and fifty parts of water, was rendered very thin by the fluid. Fehling's solution showed the presence of 0.96 Gm. glucose. It coagulated the albumen of an egg, and when kept in one-fourth per cent. solution of salicylic acid it showed no appreciable change; 0.195 Gm. leucin and tyrosin was obtained from it. Three decigrammes of freshly prepared lard were melted and subjected to the action of the fluid. A perfect emulsion was formed, which had not given off free fat after a lapse of twelve hours. The chemical examination showed in 100 parts: 3.65 parts of albumen, which coagulated on addition of alcohol and again was soluble in water; 8.57 parts of organic matter of various kinds; 8.09 parts of inorganic substances. Kulenkampff is inclined to the belief that the traumatism excited an inflammation in some parts of the pancreas, thus causing a constriction or obliteration of the duct of Wirsung or of some of its branches. As long as the fistula continued to discharge the patient continued to emaciate, but there was no disturbance of digestion. The urine did not contain sugar at any time. It was noticed that the secretion was more profuse during the afternoon. The patient recovered completely after the closure of the fistula.

In the next case the operator claims to have made a *probable* diagnosis before the operation.

Case 3. (Gussenbauer's Case.[52]) Male patient, musician, aged forty, who had always been in good health and was not affected by any hereditary taint, was taken suddenly ill after having, on a festive occasion, indulged too freely in the pleasures of the table. He complained of nausea and of acute pain in the stomach, and, after having taken more alcoholic stimulants to relieve the symptoms, he vomited repeatedly. In a few days he recovered from this attack and remained well for two weeks, when he discovered a swelling in the region of the stomach, which increased rapidly in size, so that after two weeks it caused a visible bulging in the epigastric region. The appetite now became impaired, the patient complained of a sensation of fulness after meals, accompanied by frequent eructations. During the next month he vomited after meals, and became greatly emaciated. The treatment resorted to had no effect in arresting the rapid growth of the tumor, which soon became the source of radiating pains through the lumbar and sacral regions. When he was first seen by Gussenbauer, December 21, 1882, about ten weeks after the illness had commenced, he was emaciated, and his skin was pale and of a dirty grayish-brown color. Respiration thoracic, pulse full and regular. Percussion showed slight dulness on the right side (sternal region), from the third to the fifth rib, and complete dulness below the fifth rib; in the mammary line, slight dulness at the upper margin of the fourth rib, and complete dulness from the fifth rib downward; in the axillary region, slight dulness over the seventh, and complete dulness from the eighth rib. On the left side slight dulness began at the upper margin of the third, and extended to the eighth rib in the axillary line. Auscultation showed vesicular breathing on both sides of the chest. On examination of the abdomen the attention was attracted by a prominent swelling, which extended over the right and left supra-umbilical regions, and from the left costal arch into the right hypochondriac region. In the middle line the tumor measured 18½ centimetres (7¼ inches) from the xyphoid cartilage to two inches below the umbilicus; from the left costal cartilage to the right hypochondrium, 22 centimetres (8¾ inches). Over the anterior surface of the tumor, as far as it was not covered by the left lobe of the liver, percussion elicited clear, full tympanitic resonance. When the abdominal wall was pressed against the tumor the percussion became dull. On inflating the stomach it could be seen rising above the tumor, and its great curvature was easily mapped out by inspection and percussion. The transverse colon seemed to extend anteriorly over the middle of the tumor. It was movable only to a slight degree, and seemed to follow the respiratory movements. Tenderness on deep and firm pressure. No ascites. The bowels were somewhat constipated, but the stools were natural, with no admixture of fat. No abnormal constituents in the urine. The rapid growth of the tumor, and its situation in the bursa omentalis behind the stomach and transverse colon, led Gussenbauer to make a probable diagnosis of a cyst of the pancreas or of the suprarenal capsule.

As the patient was in a critical condition, and all other measures had failed to afford relief, the only hope centred on a surgical operation, which was performed December 22, 1882. An incision was made in the linea alba about five inches in length, and the peritoneal cavity was opened to the same extent. The stomach and greater omentum were seen to cover the anterior surface of the tumor. The omentum was detached from the great curvature of the stomach for about three inches, several arteries were compressed temporarily and subsequently ligated. Through the omental incision the tumor came into view, covered by peritoneum. Fluctuation was now distinctly felt in the tumor. The upper and lower portions of the incision were closed, the parietal peritoneum was sutured to the external skin, and the anterior surface of the cyst to the margins of the wound. Through one of the punctures in the cyst-wall a dark-brown fluid escaped, and, as the suture was tied, the opening enlarged and the fluid escaped in a jet. A part of the contents of the cyst was evacuated by means of a trocar, in order to diminish the intra-cystic pressure and allow a more perfect fixation of the cyst walls to the wound. When this had been done an incision three centimetres (an inch and a quarter) in length was made into the tumor and from which altogether nineteen hundred cubic centimetres (nearly four pints) of fluid escaped. Exploration of the interior of the cyst with the finger and sound indicated no traces of a solid tumor, but a smooth membrane lining the inner walls. The lower portions of the cyst-walls were covered with black masses which were easily detached and removed without giving rise to bleeding. The cavity was washed out with a solution of thymol, a large drainage-tube was introduced, and an iodoform dressing applied. The fluid was of a grayish-black color, and contained in suspension large quantities of pigment masses, and a few red corpuscles in

a state of degeneration, representing all forms of retrograde changes. The specific gravity of the fluid was 1.610, and its reaction alkaline. The dark color was due to the pigment, which was found to be soluble in concentrated caustic soda and in acid alcohol. Spectrum analysis showed the presence of hæmatin, but not of hæmoglobin. Further tests showed that it contained albumen, a body resembling mucin, and a material soluble in alcohol, but no bile-pigment, metalbumen, peptones, or sugar. When the dressings were changed on the third day the skin appeared to be macerated, which necessitated in the future a daily change of dressing. The patient was relieved promptly by the operation, and the wound healed without suppuration. After a few days the discharge from the fistula became clear, and on examination it was found to contain leucin and tyrosin. Its reaction was alkaline, it digested albumen, and converted starch into sugar. The patient made a good recovery, and was dismissed three weeks after the operation, with a small fistulous opening, which continued to discharge a small portion of pancreatic fluid. During the period he was kept under observation the fistula closed several times, and each time he suffered from a rise in temperature, which continued until the fistula opened and discharged again.

The next three cases of cyst of the pancreas were mistaken for ovarian cysts, and the operation of ovariotomy was performed, when the nature of the cyst was discovered—in one instance during the operation, and in the remaining two at the necropsy.

Case 4. (Bozeman's case.[53]) The patient was a lady forty-one years of age and perfectly healthy, with the exception of occasional attacks of indigestion, up to within seven years before coming under observation. At this time she began to have pain in the right iliac region, extending down the right thigh, and at times attended with numbness. Two years later the abdomen began to enlarge upon the left side, and the swelling increased slowly until within the past six weeks, when it had grown rapidly. Finally it filled symmetrically the entire abdominal cavity. At the same time the patient became emaciated and weak. Dr. T. G. Richardson, of New Orleans, who examined her at this time, diagnosticated the case as one of cystic tumor of one of the ovaries, and advised the patient to consult Dr. Bozeman. The patient entered the Woman's Hospital in New York, November 19, 1881, where she came under Dr. Bozeman's care. The previous diagnosis was confirmed by Drs. Bozeman, Thomas, and Emmet, and on December 2d an operation was performed for the removal of the supposed ovarian cyst. Full antiseptic precautions were observed before and during the operation. When the tumor was reached through an incision below the umbilicus, its appearance was identical with that of an ordinary ovarian cyst, only that its color was of a more deep pearly hue. With a trocar, two and a half gallons of fluid were evacuated. After the fluid had nearly all escaped, about two-thirds of the cyst was drawn through the incision, and then for the first time the operators' suspicions were aroused that it was not ovarian. An exploration of the abdominal cavity revealed the presence of both ovaries in healthy condition. The origin of the cyst was traced to the upper part of the abdomen. The incision was enlarged upward two inches above the umbilicus. Further examination showed that the stomach had been crowded against the diaphragm by the tumor, while the intestines were displaced in an opposite direction. The cyst was found adherent to the transverse meso-colon. In tracing the cyst-walls still farther the pancreas was reached, when a large vein was discovered, which was very tortuous and was subsequently identified as the splenic. As this vein was in close relationship to the pedicle, its presence rendered the operation more difficult. The tail of the pancreas lay in contact with the side of the cyst-wall, and was firmly adherent to it to the extent of two inches. When this portion was separated the organ spread out and presented its natural appearance. The cyst sprang from the pancreas at the junction of the outer with the inner two-thirds, the pedicle being three-fourths of an inch in length, and about the same in thickness. The veins of the pedicle were very large. The pedicle was transfixed and secured in a double ligature, and cut off. On examination of the cyst it was discovered that a portion of it remained attached to the pedicle; this was subsequently completely removed by a careful dissection. The artery which supplied the cyst was as large as the brachial, and appeared to be a branch of the splenic. Very little bleeding attended the operation, and no ligatures were required. The fluid removed was of a light brownish color, of acid reaction, and with a specific gravity of 1.020. The tumor and its contents weighed twenty and one-half pounds. Quinine, stimulants, and opiates were given after the operation. The highest temperature, 101.5° F., was noted on the third day; the pulse never rose above 98. After omitting the quinine, the temperature rose to 102.8° F., on the eighth day, when quinine in ten-grain doses every six hours reduced the temperature to nearly normal in the course of thirty-six hours. From this time the improvement continued uninterruptedly to the time when the patient was discharged cured, on the thirty-eighth day.

Case 5. (K. von Rokitansky's case, reported by Zukowski.[54]) The patient was a woman, thirty-six years of age, who had suffered with symptoms indicative of ovarian cyst for nearly three years. The tumor was first noticed in the upper portion of the abdominal cavity. Laparotomy was performed February 27, 1881. The usual incision was made in the linea alba, and the supposed ovarian cyst was found behind the great omentum, stomach, and transverse colon. The cyst-wall adhered firmly to the surrounding organs, and on attempting to separate the adhesions between it and the transverse colon a rent was made in the bowel two centimetres (¾ inch) in length. The tear was at once closed with five sutures. The adhesions were so numerous, firm, and vascular, that complete extirpation of the entire cyst was found impossible, consequently the detached portion was crushed off with an écraseur, the stump fastened in the abdominal incision, and the wound drained and closed. During the operation the cyst ruptured, and a portion of its contents escaped into the peritoneal cavity. Fifty ligatures were applied in preventing and arresting hæmorrhage. After the operation the patient collapsed and nearly died on the table. She rallied from the immediate effects of the operation, but died on the tenth day from suppurative peritonitis. Some time before death fæcal matter escaped through the opening left by the drainage-tube. At the autopsy it was shown that the remaining portions of the cyst were connected with the pancreas. Of this organ only the head was found in a normal condition, of the body only a few remnants remained, while the tail had disappeared completely.

Case 6. (Luecke's case, reported by Luecke and Klebs.[55]) A woman, forty-three years old, had always been in good health, with the exception of bronchial catarrh. In July, 1866, at the time when menstruation should have appeared, she experienced a severe pain in the right hypochondriac region, where a swelling soon after made its appearance. The tumor gradually increased in size and soon occupied the entire abdominal cavity. During the menstrual period the swelling always became tender and painful. She was admitted to the hospital, under Luecke's care, November 29th of the same year, and then appeared pale and emaciated. She complained of difficulty in breathing, but all the other functions were unimpaired. The abdomen was symmetrically enlarged, its greatest circumference measured 95 ctm. (37½ inches). The distance from the xyphoid cartilage to the umbilicus measured 14 ctm. (5½ inches); from the umbilicus to the pubes 18 ctm. (7 inches). Percussion revealed dulness over the middle of the abdomen as far as half-way between the umbilicus and xyphoid cartilage. The lumbar regions were tympanitic. An examination through the vagina and rectum showed that the uterus was displaced backward and toward the left side; upon its posterior surface a hard nodule could be felt. The tumor appeared to have no connection with the uterus. On December 1st menstruation set in with severe pain in the lower part of the

patient. No change in temperature or pulse rate occurred. On December 6th the tumor was tapped at a point to the left of the median line and twenty-three pints of a turbid yellowish fluid were evacuated. After tapping, a movable tumor was felt in the left side of the abdominal cavity, which was regarded as the collapsed sac of the ovarian cyst. The fluid removed contained only a small amount of albumen. The microscopic examination showed the presence of large, pale cells, some of them filled with granular matter. The condition of the patient was considerably improved by the tapping. Four days after the operation the cyst was again filling rapidly, and on percussion it seemed to occupy the middle of the abdomen, its upper margin being somewhat below the umbilicus. On December 22d the labia majora and lower extremities were œdematous, and the tumor was as large as before tapping. On January 1, 1867, the patient suffered from a severe attack of dyspnœa during the night; at this time the area of dulness over the tumor had extended to within two inches of the ensiform cartilage, the umbilical depression was effaced, and the lumbar regions were resonant on percussion. On the following day the patient was removed to a private dwelling, where abdominal section was performed. After cutting through the skin and the muscular layers in the linea alba, a thin, smooth, and very vascular membrane was seen to protrude through the wound. Through a small puncture which was made into this membrane, a milk-white fluid escaped. The trocar was pushed through the membrane, and a large amount of the same fluid poured out. On making traction upon the membrane the umbilical depression was restored. This circumstance, as well as the difficulty which was experienced in an attempt to separate the membrane, and the prolapse of the small intestine which now occurred, combined to prove that the supposed cyst-wall was the parietal peritoneum. The abdominal cavity was opened, and on exploration both ovaries were found normal in structure and in position. The abdominal wound was closed with two rows of sutures. The fluid removed measured twenty-seven and a half pints and resembled milk in its gross appearance; it coagulated spontaneously, and contained in suspension the same morphological elements as the fluid removed by tapping, with the exception that in addition numerous fat-globules were found. The patient died January 5th, the symptoms indicating during her illness the presence of diffuse peritonitis. The post-mortem examination was made by Professor Klebs. The intestines were crowded upward, the transverse colon was studded with numerous white or myxomatous nodules, was very much contracted, and formed a curve with the concavity directed upward, being separated from the stomach by a cyst with thin walls. The anterior wall of this cyst was made up of the lesser omentum. On opening the cyst a large quantity of fluid escaped, resembling in every particular the fluid which had been removed from the peritoneal cavity. The floor of the cyst was covered with nodules composed of grayish, jelly-like masses. The principal portion of this material belonged to the pancreas. This organ had been transformed into a mass four inches in width and twelve inches in length, and was composed almost entirely of gelatinous nodules; in the centre of the mass the common duct could be identified. The mesentery contained numerous miliary nodules, and in Douglas's pouch large nodular masses were found. The left lateral ligament also contained gelatinous nodules. The other abdominal organs were healthy. The microscopical appearances were characteristic of colloid cancer. The disease had evidently had its origin in the pancreas.

Case 7. (Reported by Thiersch.[56]) A case of pancreatic fistula was admitted to the hospital with the following history: The patient, a stone-cutter, thirty-eight years of age, in previous good health, was taken suddenly ill while at work. He complained of nausea and a sensation of great lassitude. A tumor developed rapidly in the region of the stomach. The rapidity with which the tumor appeared, and the distinct fluctuation which could be felt, led the attending physician to diagnosticate an abscess in the anterior abdominal wall. An incision was made to evacuate the contents of the abscess, but in place of finding pus the operator, after cutting through the peritoneum, discovered a cystic tumor of the abdominal cavity. The wound was packed, and incision of the cyst was postponed until adhesions should form between the anterior surfaces of the tumor and the margins of the wound. Two and a half weeks after the incision was made the cyst was laid open, and about three quarts of a chocolate-colored fluid escaped. As the fistula which formed manifested no tendency to close, the patient sought relief in the hospital. The fistula secreted a moderate amount of a thin, serous fluid. The chemical examination for pancreatic juice yielded a negative result. Thiersch dilated the fistulous tract, and ascertained by further examination that the tract was outside the parietal peritoneum, and reached as far as the spinal column and the tail of the pancreas. Thiersch was of the opinion that the cyst originated from a hæmatoma of the pancreas, and considered this the first case of recovery after such a lesion.

Case 8. Dixon[57] reports an interesting case of cyst of the pancreas, which terminated in death from compression of the bile-duct by the cyst. The patient was a man, forty-two years of age, who during a period of three months had suffered from three attacks of what seemed to be cholelithiasis, before he came under the reporter's care. During the last ten days he had been jaundiced. On examination, a tumor was found in the region of the gall-bladder, about four inches in diameter, which fluctuated on palpation and ascended and descended synchronously with the respiratory movements, and received an impulse from the underlying aorta. The tumor was punctured, and four ounces of a yellowish-red fluid were removed, which solidified on exposure to the air. Two days after the puncture the tumor was considerably larger than before. The patient's strength gradually failed until he died, thirty-four days after the puncture. At the necropsy, it was ascertained that the tumor was a cyst of the pancreas, with thick walls, and light yellow mucous contents. The cyst occupied the head and part of the body of the gland, and communicated with the pancreatic duct. The tail of the pancreas also contained a small cyst. The large cyst compressed the ductus choledochus in such a manner as to render it entirely impermeable. It is evident that in this case a removal of the pressure by operative treatment might have restored the health of the patient, by removing the cause of obstruction to the natural outlet for the bile.

Case 9. (Reported by Riedel.[58]) A woman, forty-five years of age, noticed nine years ago a small tumor in the upper portion of the abdomen, which increased slowly in size until a year and a half before she was examined by Riedel. After this time growth was very rapid, so that recently a great deal of pain and distress was experienced from the size of the tumor. When she was examined, the abdomen was filled completely with a fluctuating tumor; the pelvis and the lateral regions of the abdomen were free. Laparotomy was performed August 27, 1884. The slightly adherent omentum was easily separated, the cyst was tapped, and about ten litres of a brownish fluid escaped. After evacuation of the cyst, the transverse colon could be seen immediately behind the symphysis pubis. The meso-colon had been separated with the omentum. The cyst was separated from the loose attachments with neighboring organs. Troublesome hæmorrhage occurred only from the deeper portion of the wound, near the vertebral column, where a ligature *en masse* was applied and several vessels tied; the cavity of the wound, the size of two fists, was dusted with iodoform. Death from peritonitis occurred at the expiration of ninety-six hours. At the necropsy a portion of healthy pancreatic tissue was found ligatured with the catgut. The interior surface of the cyst showed, for the most part, a smooth surface without epithelium. At different points it presented prominences which contained glandular tissue.

Case 10. (Reported by Salzer from Billroth's clinic.[59]) A woman, thirty-three years of age, unmarried, suffered from an attack of typhus fever when she was eighteen

years of age. On admission into the hospital she stated that during her convalescence she noticed a swelling the size of a goose-egg in the middle of the abdomen above the umbilicus, which disappeared in a few weeks. Four years later the swelling reappeared in the same place; it was now the size of a fist, but little movable, and rendered the umbilical region prominent. The size of the tumor increased gradually, until four years ago it had attained the size of a fœtal head, and had descended below the umbilicus. A sensation of weight in the stomach, vomiting, and pain in the abdomen had been the most prominent symptoms during the last fourteen days. Menstruation was regular. Before the operation a systematic and careful examination showed no disease in any other organ. The circumference of the abdomen below the umbilicus was ninety centimetres (thirty-five and a half inches). An unusually large vessel was detected in the abdominal wall in the left hypochondrium, which pulsated strongly, and over which, on auscultation, a bruit could be heard. The abdomen was prominent, especially in the median line. On palpation the swelling was recognized as a round, smooth, fluctuating tumor, which was in direct contact with the anterior abdominal wall, and could be moved slightly from side to side. Percussion dulness existed over the entire area of the tumor. Both lumbar regions were resonant. Spleen and kidney dulness normal. A vaginal and rectal exploration showed that the uterus was pushed toward the right side, but movable. Behind the uterus a firm tumor could be felt. The diagnosis made at the time was unilocular cyst of the left ovary. Laparotomy was performed on June 5, 1885. Median incision exposed the omentum over the cyst, slightly adherent. An opening was made in the omentum with blunt instruments, through which the cyst-wall became visible. The hand, introduced through this opening, showed the existence of firm adhesions of the cyst-wall to the neighboring organs. After enlarging the external incision the gastro-colic ligament could be seen stretched over the cyst. The transverse colon lined the lower border of the cyst, and had descended behind the symphysis pubis. When this portion of the intestine was elevated, it was seen that the cyst belonged to the meso-colon. The separation of the cyst presented many difficulties, consequently its size was reduced by tapping, the opening was closed with pressure-forceps, and enucleation was begun through a vertical slit in the gastro-colic ligament. Numerous mass-ligatures had to be applied to arrest troublesome hæmorrhage.

On the left side of the cyst the same enlarged vessel was met with that could be felt externally; it was found so intimately adherent to the cyst-wall that it could not be isolated; a double ligature was therefore applied around it and the accompanying veins, and the vessels were divided between the ligatures. To facilitate the deep dissection the incision was enlarged upward, and the cyst opened and emptied, with the patient lying upon the side. The hand was introduced into the cyst, when it was found that the attached portion extended in an upward direction. The artery previously ligated had to be tied again higher up. In completing the tedious enucleation no pedicle was found.

From the position it could be ascertained that the base of the cyst was in the vicinity of the pancreas. After careful arrest of hæmorrhage at the bottom of the wound, and the usual toilet of the peritoneum, the external wound was closed completely, no drainage being used. The patient, who was suffering considerably from shock, rallied after the administration of stimulants. In the evening the temperature was 37.6° C. (99.7° F.); pulse, 72; pain in abdomen, and nausea. Restless during the night. During the next few days the pulse was more frequent, there were jaundice and diarrhœa, great restlessness, and collapse, which terminated in death on the sixth day after the operation. At the autopsy extensive purulent peritonitis was found to have been the cause of death. In the transverse meso-colon a hole was found through which a fist could be passed. Through this opening a cavity, the size of a fist, was entered, the walls of which were infiltrated with blood and pus. In the bottom of this cavity the exposed pancreas was seen, which appeared to be divided transversely behind the head. Along the margin of the pancreas the splenic artery and vein were found and ligated, and portions of both vessels were excised. The middle portion of the pancreas was absent. A part of the tail of the organ, five centimetres in length, remained. The spleen was enlarged to twice its normal size, but was otherwise normal in structure. The other organs were healthy. A microscopical examination of the cyst showed that its walls contained pancreatic tissue. Its inner surface was not lined with epithelial cells.

Case 11. (Reported by Kramer, operation performed by Hahn.[60]) A girl, sixteen years of age, after an attack of vomiting and pain in the abdomen, noticed a gradual distention of the upper portion of the abdominal cavity. The size of the tumor and the area of dulness corresponding were about the same as in my case. The dulness appeared to be continuous with the hepatic dulness. A diagnosis was made of echinococcus cyst of the liver. Laparotomy was performed, and the omentum was divided between the stomach and the transverse colon. About two litres of an albuminous fluid were removed by tapping. The cyst was stitched to the margin of the abdominal wound, incised, and drained. The patient recovered, with an external pancreatic fistula which continued to secrete pancreatic juice for four months.

Pathology and Morbid Anatomy.—Cysts of the pancreas always result from retention of the secretion and subsequent dilatation of the duct, or, in case of laceration of this structure, from extravasation of the secretion into the parenchyma of the gland and subsequent distention of its capsule. The size of the cyst is modified by the character and seat of the obstruction, and by its relative position to the secreting gland-structure. The walls of the cyst are usually thinned from over-distention in cases of rapidly growing cysts, or much thickened when the growth of the tumor has been slow and accompanied by chronic proliferation and induration of the connective tissue. The cyst-walls in chronic cases may become cartilaginous, or even ossified. The inner surface is either smooth, or it presents evidences of degeneration similar to those which occur on the internal surface of arteries in the later stages of endarteritis. If the canal of Wirsung is obstructed at or near its proximal end, the entire duct and its branches may become dilated, presenting the appearance of varicose veins, or a more uniformly rounded cyst may form, of the size of an orange or of a child's head, or even so large as to occupy the whole abdominal cavity, as in Bozeman's case. As the cyst increases in size, the gland-structure disappears by absorption in consequence of intra-cystic pressure. The same cause which constitutes the obstruction will often also lead to destruction of the parenchyma of the organ, by inducing a chronic interstitial pancreatitis, which is followed by cirrhosis or fatty degeneration of the organ. Virchow[61] alludes to cysts of the pancreas under the name of ranula pancreatica, and describes two essential and distinct varieties. In the first class the entire duct is found dilated, with occasional points of constriction, and resembles in appearance a rosary. In the second variety the outlet of the excretory duct is obstructed, and behind the seat of obstruction the duct undergoes cystic dilatation. He mentions a case that came under his observation in which such a cyst had attained the size of a fist.[62] He believes that cicatricial contractions or pressure of tumors upon the duct constitute the most frequent source of obstruction. Pancreatic juice in its purity is only found in small and recent cysts. Later on, in old or large cysts, various accidental products are added. Albuminoid degeneration or suppuration not infrequently takes place, or hæmorrhage may occur, so that the contents of the cyst assume a bright-red or chocolate-colored appearance. Pepper found in such a cyst numerous crystals of hæmatoidin, while Hoppe found in another instance urea, in the proportion of 0.12 per cent., as one of the constituents of the contents of the cyst. The pressure of the cyst upon the neighboring organs will result in secondary pathological conditions

which will interfere with the physiological performance of the functions of other organs, thus endangering the life of the patient.

Etiology.—The causes which result in the formation of small cysts of the pancreas or cysts which result from compression by tumors which in themselves do not admit of an operation for their removal, and at the same time constitute a source of danger to life do not come within the scope of this article. In the latter instance the cyst is simply a sequence of the primary cause, and as such it will seldom, if ever, become the sole or direct object of surgical treatment. The causes of retention in cysts amenable to operative treatment are such as, in themselves, do not imperil the life of the patient. They may be classified as follows: 1. Obstruction to the outflow of the secretion from impaction of calculi in the common duct or its branches. 2. Partial or complete obliteration of a portion of the duct from cicatricial contraction. 3. Sudden or gradual obstruction of the duct, without diminution of its lumen, from displacement of the pancreas.

1. Calculi. The impaction of the pancreatic duct at its outlet may be caused by the presence of a biliary calculus in the ductus communis choledochus, at the junction of the former with the latter. A case of this kind has been reported by Engel.[63] In such cases the obstruction gives rise to retention of the secretions from the liver and the pancreas, and dilatation of the excretory ducts in both organs. Calculous concretions in the pancreatic ducts have been frequently observed to give rise to retention-cysts. Johnson[64] has collected thirty-five cases in which, upon post-mortem examination, stony concretions were found in the pancreas. Incrustations are not as frequent as free concretions. Gendrin has described a pancreatic cyst in which the normal pancreatic secretion was converted into a fatty, chalky pap. The causes which produce a concretion in the pancreatic duct are chemical changes in the secretion itself, or an obstruction to its free exit by inflammatory changes in or around the common duct. The degree of dilatation, other things being equal, is in direct proportion to the completeness of the obstruction to the outflow of the secretion. It may be well to allude to the possibility that in some instances a pancreatic calculus may remain stationary for an indefinite period of time in the duct, and give rise to no symptoms, and only partial obstruction, until, by the action of some determining cause, it is forced into a position where it effects complete mechanical obstruction to the outflow of the fluid, and a rapid increase in the size of the cyst. As an impacted biliary calculus may give rise to pancreatic obstruction, so a pancreatic calculus, when it is impacted at a point where compression of the common bile-duct can take place, will produce icterus and dilatation of the gall-bladder and bile-ducts. Meckel[65] has reported such a case.

Among the specimens of pancreatic cysts, so far examined, which were caused by concretions, none had attained the size of those which have been submitted to surgical treatment. As in most of these preparations the calculi did not completely fill the calibre of the duct, they caused only partial obstruction, which fact would furnish an explanation of the slow growth and comparatively small size of the tumor. In the specimen described by Gould,[66] it appears that the common duct was completely closed by two calculous concretions at its entrance into the duodenum, and this cyst had attained considerable size; in fact, it is the largest cyst on record in which it was proved that the dilatation was caused by the presence of a calculus. As in the successful operation on cysts of the pancreas it was impossible to ascertain the exact nature of the obstruction, the possibility of retention from a calculus cannot be eliminated with certainty.

2. Cicatricial Contraction. Cicatricial contraction is always the result of an antecedent inflammation. The cicatrix may be located in the peri-pancreatic tissue or in the substance of the gland itself. Hopper[67] made a post-mortem examination of a patient who had been deeply jaundiced during life. The gall-bladder and bile-ducts were distended with bile which contained blood; the pancreatic duct was also cylindrically dilated, and many of its branches were distended into cysts the size of a hazel-nut. The cause of retention of both secretions was found in a dense cicatrix which surrounded both ducts at their duodenal termination. Interstitial inflammation in the gland itself, and subsequent cicatricial contraction, is one of the most frequent causes of retention. Wyss[68] has reported a case in which the interstitial inflammation was limited to portions of the head of the pancreas, through which the common bile-duct and the duct of Wirsung passed, and which had resulted in dilatation of the latter and of its branches which again compressed the bile-duct, producing in this manner intense icterus. Bécourt[69] has given a description of a similar specimen which he found in the Strassburg Pathological Museum. The patient had died of icterus. The gall-bladder and bile-ducts were found distended; the pancreas was converted into a dense tissue which, being cut into, presented a chalky deposit four to eight inches in length and of a yellowish color. The duct of Wirsung was dilated to such an extent as to form a large cyst which occupied the whole length of the pancreas, its walls being inseparable from the substance of the gland. In this case the interstitial inflammation was more extensive and the cyst was much larger. In the cases reported by Pepper and Hjett the obstruction was due to the same cause. In Curnow's[70] case the common duct had become obliterated at its entrance into the duodenum by catarrhal inflammation. The pancreas was atrophied, and its duct was filled with numerous calculi. The pancreatic juice had become inspissated. The cystic duct of the gall-bladder was impermeable, while in the common bile-duct a number of small gall-stones were found.

I have failed to find in the literature an allusion to stricture of the duct the result of traumatism. The pancreas is an exceedingly slender organ, of loose and somewhat friable texture, and hence, although remotely located and well-protected by surrounding organs, I am of the opinion that it is more frequently the seat of injury than has been generally supposed. If the stomach is empty and the abdominal muscles relaxed, a blow over the region of the pancreas may result in serious contusion or laceration of the organ, without rupture of its envelope. Again, a well-directed blow over either extremity of the gland may cause a laceration of its tissues by traction-force, the organ being securely fixed in its place by firm connective-tissue attachments. The clinical history of several cases of rapidly growing cysts tends to prove that obstruction occurred in this manner. If the duct escapes injury, the cicatricial contraction attending and following the reparative process in the lacerated gland-tissue will gradually compress the duct, or by lateral traction change its direction and thus impede the outflow of the secretion. If the duct is ruptured at the time of injury, its lumen may become completely filled by a thrombus, which renders it impermeable, giving rise to retention and extravasation of the secretion primarily, and secondarily to definitive occlusion of the duct by cicatricial contraction at the point of injury. I am quite convinced that, in the case which I have reported, the retention was the direct result of traumatic stricture of the common duct. Although this view is not supported by evidence from post-mortem examinations, it is confirmed by the analogous production of cysts in other locations. It is evident that this class of cases would furnish the most favorable conditions for successful surgical treatment.

3. Obstruction from Displacement of the Pancreas. As the pancreas is retained in its normal transverse position by the surrounding organs and connective-tissue attachments, a relative change of position of portions of the gland would result in a bending of the organ, and obstruction in the duct at the point of flexion. This condition was the cause of retention in a case related by Engel,[71] who found in a woman, sixty years of age, that the tail of the pancreas was directed upward, forming a right angle with the remaining portion of the gland. A dislocation of this kind can occur in one of the following ways:

a. Abnormal relaxation of the connective-tissue attachments of the gland, permitting a portion of the organ to descend by its own weight lower in the abdominal cavity.

b. Pressure upon the gland by tumors or exudations.

c. Cicatricial contractions in the substance of the organ or in the peri-pancreatic space.

That the whole pancreas can become displaced is proven by the case reported by Dobrzycki.[72] A man, fifty years of age, fell a distance of some yards. Symptoms similar to those of a floating kidney appeared after the accident. By palpation the displaced organ could be located. Saline fluid resembling pancreatic juice was vomited. In the hypogastrium a movable tumor, corresponding in position and shape to the pancreas, could be felt.

The experiments made by the author[73] for the purpose of ascertaining the effect of complete and permanent obstruction of the pancreatic duct have demonstrated conclusively that obstruction is not the only nor the most important element in the causation of a pancreatic cyst. That the ligated portion of the pancreas continued to secrete pancreatic juice was demonstrated by the experiments on external pancreatic fistulæ, and yet, in many cases of ligation of the pancreas, in not a single instance was a cyst, or even an attempt at the formation of a cyst, observed. The only physical evidence of obstruction was apparent in a moderate and uniform dilatation of the duct behind the ligature. The most important etiological factor in cases of cyst of the pancreas must be sought in an arrest of absorption of the pancreatic juice, due either to a transformation of this fluid, by the admixture of pathological products, into a substance which is incapable of being absorbed, or to a loss of function in this direction of the vessels which perform the task.

The obstruction in the pancreatic duct may cause retention and accumulation of pathological products, but can never be the sole cause of retention of pancreatic juice in an otherwise healthy portion of the pancreas. In the cases in which normal pancreatic tissue was found in the cyst-walls, it was more than probable that the pathological condition which had caused the obstruction did not effect complete physiological detachment of the peripheral portion of the pancreas; in other words, the obstruction was not complete. In cases in which complete physiological detachment has taken place, either by the application of a ligature or through complete obliteration of the duct by pathological conditions, parenchymatous degeneration and atrophy in the detached portion are such constant results that the exceptions to this rule must indeed be few, if any.

Diagnosis.—The question of diagnosis can only be entertained in cases in which the cyst has attained very considerable proportions. The most important points to be taken into consideration are the history of the case, the anatomical location of the tumor, and its relations to the surrounding organs. The cases which have been reported have occurred exclusively in adults. Sex appears to exert no determining influence. In a number of cases the clinical history alludes distinctly and forcibly to traumatism as the exciting cause. In Gussenbauer's case the beginning of the illness was traced to indiscreet eating and drinking.

In all instances of cystic tumors in the region of the pancreas, close inquiry should be made to ascertain the existence of antecedent inflammatory affections of the organ, or of parts in its immediate vicinity. A history pointing toward the existence of a biliary or pancreatic calculus will also prove valuable in arriving at positive conclusions. Rapid growth of the tumor speaks in favor of its pancreatic origin. In Gussenbauer's, Kulenkampff's, and my own cases, the tumor attained an enormous size within a few weeks. Considering the relations of these cysts to important surrounding organs, it is remarkable that they give rise to no serious symptoms aside from the pressure they exert upon adjacent organs. Pain is not a constant symptom, and when it is present it is due more to the causes which produce the cyst than to the cyst itself. In this respect cysts of the pancreas form a counterpart to malignant disease when it affects this or neighboring organs. Emaciation is due either to co-existing affection of the gland, or to the impairment of function of important organs by pressure from the cyst. It is never as marked in these cases as in malignant disease. The supervention of fatty stools would point toward the existence of some co-existing serious lesion of the pancreas rather than to the existence of a simple cyst of the organ. This symptom was not present, or it was overlooked, in all cases which have been operated upon. Of 28 cases of stearrhœa which were compiled by Ancelet, 16 were examined post-mortem. In 5 of these there was occlusion of the ductus choledochus and pancreaticus; in 3, occlusion of the pancreatic duct alone; in 1, inflammation of the pancreas and some of the adjacent organs. In the remaining cases disease of the liver and of the bowels, or only marasmus, was found. In 13 cases of pancreatic calculi collected by Johnston, in only 3 were fatty stools observed; in 6 cases diarrhœa, in 4 cases melæna, and constipation in the remaining 6. The presence of fat in the stools is a symptom of great importance in the recognition of pancreatic disease, but that it is not of absolute diagnostic significance is proved by the well-known fact that the same condition will follow upon the obstruction of the biliary passages and affections which impair the functional activity of other organs of digestion.

Obstruction of the principal duct impairs digestion more than when its distal extremity or one of the accessory ducts is involved. The actual illness of the patient is usually preceded, for a variable length of time, by more or less marked symptoms of gastro-intestinal derangement, accompanied in some instances by pain in the region of the pancreas.

A peculiar color of the skin, which is believed by some to be characteristic of the pancreatic disease, must be mentioned, as it was observed in several cases of calculous affection and cysts of the pancreas. The appearance presented by these patients is variably described as being unhealthy, pale yellow, dirty, or earthy. The intimate relations of the cyst to the cœliac plexus will explain the cause of cœliac neuralgia, which is met with in some of these cases. Atrophy of the cœliac plexus, from long-continued pressure, may give rise to melituria, for the same reason that Klebs has affirmed that partial extirpation or atrophy of the cœliac plexus will cause the presence of sugar in the urine. Divers diseases of the pancreas have also been known to produce diabetes mellitus. Cases of this kind have been reported by Cowley (1788), Bright, Eliotson, Frerichs, Fles, Hartsen, Silver, Recklinghausen, Munk, Seegen, and Friedreich. Klebs demonstrated by his experiments that complete extirpation of the pancreas, or ligature of its duct, invariably gave negative results as far as diabetes was concerned, and this may account for the fact that no sugar was found in the urine of the cases reported under this head. The cyst, when examined early, before it has attained considerable size, is always found in the region normally occupied by the pancreas. The exact location, however, is not always uniform, as it will depend upon the portion of the pancreas from which the cyst has taken its primary origin. It may be situated below the right lobe of the liver, as in Kulenkampff's case; in the epigastric region, as in Gussenbauer's case; or in the left hypochondrium, as noted in my case. When the tumor has attained a large size, or occupies the whole abdominal cavity, it will be difficult, and, in the latter instance, impossible, to determine by any known means its primary origin. In such cases it is of paramount importance to study its relations to adjacent organs. The tumor is always and invariably situated in the bursa omentalis, and from this point, as it increases in size, it encroaches upon the space occupied by adjacent organs. The stomach is pushed forward in all cases, and later to the right. The transverse colon is displaced downward, the spleen to the left, and the diaphragm and contents of the chest upward. The cyst being in direct contact with the diaphragm, it usually ascends and descends with the respiratory movements of the chest.

In doubtful cases it will become necessary to inflate the stomach and colon, with a view to ascertain their

relative position to the cyst. If the patient is a female, and the tumor occupies the entire abdominal cavity, it will simulate cystic disease of the ovary so closely that a differential diagnosis between the two is impossible. The cases reported by Luecke, Bozeman, and Rokitansky furnish adequate proof of the correctness of this statement. The proximity of the abdominal aorta is such that the impulse of the artery is imparted to the tumor, which, however, pulsates only in one direction—away from the artery—a fact which will always distinguish it from aneurism. Unless the cyst is exceedingly tense, a sense of fluctuation is always imparted by palpation. Palpation is rendered difficult on account of the deep location of the pancreas and the rigidity of the recti abdominis muscles. The normal pancreas can be felt only under certain favorable conditions. Concerning this point Sir William Jenner says: "By deeply depressing the abdominal walls about a hand's-breadth below the umbilicus, by then rolling the subjacent parts under the hand (the stomach and colon must be empty), it might be possible to detect it in an individual who is thin, and whose tissues are lax." In case the examination is rendered difficult on account of great rigidity of the abdominal muscles, this obstacle can be overcome by examining the patient under the influence of an anæsthetic. An exploratory puncture with a fine and perfectly aseptic needle of a hypodermic syringe will not only add material diagnostic information by revealing the character of the cyst-contents, but the procedure will also settle the question as to the existence or absence of adhesions between the cyst-walls and the parietal peritoneum. In the differential diagnosis the following affections will come up for consideration: 1, Malignant disease of the pancreas or adjacent organs; 2, aneurism; 3, echinococcus of the liver, spleen, or peritoneum; 4, affections of the retro-peritoneal lymphatic glands; 5, hydro- or pyonephrosis; 6, cystic disease of the suprarenal capsule; 7, circumscribed peritonitis with exudation; 8, ascites; 9, cystic disease of the ovary.

1. Malignant Disease of the Pancreas or Adjacent Organs. Carcinoma or sarcoma of the pancreas or adjacent organs, as in every other locality, always manifests its presence by its most characteristic clinical features—pain, emaciation, and progressive local and general infection. The age of the patient and the previous history of the case will also furnish important diagnostic information. Large pancreatic cysts are unilocular, while, on the other hand, if a malignant tumor has undergone cystic degeneration, usually more than one cyst can be recognized. Hardness and irregularity of the surface speak in favor of malignancy; on the other hand, smoothness and a regular round or oval contour of the tumor are constant features of a pancreatic cyst. The time which has elapsed since the beginning of the illness is also of importance. A rapidly growing pancreatic cyst will assume a size in two or three weeks which, even for a malignant tumor, would require as many months.

2. Aneurism. An aneurism of the abdominal aorta can be distinguished from a pulsating pancreatic cyst by its pulsations being felt in all directions, and by the presence of a bruit. As a further test, the suggestion of Dr. Pepper may be resorted to, which consists in placing the patient in the genu-pectoral position, when the tumor, by gravitation, will leave the aorta and all pulsation will cease. Steady pressure will diminish the volume of an aneurism, but will have no effect on a cyst of the pancreas.

3. Echinococcus Cysts. An echinococcus cyst of the liver, spleen, or peritoneum could be easily mistaken for a cyst of the pancreas. The peculiar fremitus sometimes felt on palpating an echinococcus cyst should always be sought for. Multiplicity of cysts would decide in favor of something else than a pancreatic cyst. The presence of hooklets in the aspirated fluid would furnish positive evidence of an echinococcus cyst, while their absence would not exclude the possibility of the tumor being a sterile echinococcus cyst. As the surgical treatment in both instances would be identical, it is sufficient, for practical purposes, to narrow the diagnosis down to a probable existence of either affection.

4. Affections of the Retro-peritoneal Lymphatic Glands. Neoplasms, inflammation, suppuration, or hypertrophy of the retro-peritoneal glands behind the pancreas might simulate a pancreatic cyst, and as a wrong diagnosis in such an event might prove disastrous to the patient and reflect discredit upon the surgeon, every diagnostic resource should be exhausted in order to prevent such error. Enlargement of the lymphatic glands, from any cause, sufficient in extent to simulate a pancreatic cyst, would almost of necessity give rise to serious constitutional disturbances and extension of the disease to neighboring organs.

5. Hydro- or Pyo-nephrosis. In hydro- or pyo-nephrosis, the early clinical history will present a group of symptoms pointing toward some lesion in the pelvis of the kidney, or in the ureter. A chemical and microscopical examination of the urine may furnish conclusive evidence of the existence of some renal affection which has produced the obstruction. Tumors of the kidney usually occupy a lower place, and are more laterally located than tumors originating in the pancreas. In the case of a pancreatic cyst, the lumbar region below the kidney is tympanitic, which is not the case in hydro- or pyo-nephrosis. In case of doubt, an exploratory puncture may enable us to arrive at a positive conclusion.

6. Cystic Disease of the Suprarenal Capsule. The suprarenal capsule may be the seat of cystic degeneration, and simulate a cyst of the pancreas so closely that a differential diagnosis is impossible. In Gussenbauer's case, the diagnosis remained doubtful between a cyst of the pancreas and a cyst of the suprarenal capsule. The bronzed skin so frequently observed in diseases of the suprarenal capsule has been also seen in affections of the pancreas. As the operative treatment in either case would be the same, it is not essential for practical purposes to make a positive diagnostic distinction between the two.

7. Circumscribed Peritonitis with Exudation. Primary peritonitis, with a circumscribed exudation in the region of the pancreas, would reveal a history pointing toward an inflammatory affection accompanied by the usual symptoms attending inflammation of this membrane. Fever, pain, and tenderness are symptoms which are either foreign to the history of cysts of the pancreas, or, when present, are less intense than in peritoneal inflammations. In peritonitis the exudation would be necessarily in the peritoneal cavity, while pancreatic cysts always occupy the omental bursa.

8. Ascites. The question of diagnosis between a cyst of the pancreas and ascites can arise only in case the whole abdominal cavity is distended by the tumor or effusion. The causes which produce ascites must be considered separately and individually, and, as they are usually of such a character as to exclude a suspicion of pancreatic disease, a satisfactory diagnosis can be reached without an exploratory puncture; but, if any doubt remains, this harmless procedure will furnish the requisite information.

9. Cystic Disease of the Ovary. From the cases reported we have gleaned that, in at least three cases, large cysts of the pancreas were mistaken for cystic disease of the ovary by surgeons of prominence and ability who made thorough and repeated examinations. It is not difficult to conceive that, in case the tumor had assumed such dimensions as to fill the entire abdominal cavity, it would be impossible to differentiate between a cyst of the pancreas and of the ovary, even by the most scrutinizing examination. The physical signs presented by either resemble each other so closely that they cannot be relied upon in discriminating one from the other. The early history of the case, if it can be obtained from a reliable source, is of more diagnostic value. In pancreatic cysts the early symptoms are usually referred to disturbance of the digestive functions, and the patient has been aware of the presence of a tumor in the upper portion of the abdominal cavity. An ovarian tumor necessarily begins in the opposite part of the abdominal cavity,

and gives rise to pelvic distress and disturbance of the menstrual function. As the surgical treatment in both instances would be the same, it is practically not essential to make a positive distinction between the two before an exploratory incision will reveal the true nature and origin of the cyst. In recapitulation, it may be stated that a positive diagnosis has so far not been made in a single instance, and that, for all practical purposes, it is only essential to make a probable diagnosis between a pancreatic cyst, and some other kind of cyst which would call for the same kind of surgical treatment. In very obscure cases an exploratory incision, under antiseptic precautions, is a justifiable procedure.

Prognosis.—Physiologists are agreed in assigning to the pancreas a most important function in the digestion of organic food. We know that by a special ferment it assists in the transformation of starch into dextrine and sugar, and in the digestion of albumens and fat. We should naturally expect that in diseases of this organ the digestion of these substances would be impaired in proportion to the amount of gland-tissue destroyed. On the other hand, we have abundant evidence to show that even total disorganization or destruction of the pancreas is not incompatible with normal digestion and perfect health. It would seem that, in the absence of the pancreatic secretion, other organs may assume a vicarious action, and digestion proceed unimpaired. It is also important to remember that even a large cyst of the pancreas does not necessarily result in extensive destruction of the gland, and that the remaining gland-tissue continues to secrete and discharge a sufficient amount of pancreatic juice. In Bozeman's case the cyst occupied the entire abdominal cavity, and yet at the operation the greater portion of the gland was found healthy in structure. The integrity of the structure and function of the gland depends less on the pressure of the cyst than on the causes which were concerned in its production.

The dangers arising from the cyst itself consist in: 1, Its interference with the functions of other abdominal organs by pressure; 2, rupture of the cyst and escape of its contents into adjacent hollow organs or into the peritoneal cavity. Compression of the stomach and interference with its normal peristaltic action is a constant occurrence when the cyst has developed to any considerable size. When such is the case, vomiting soon after meals takes place, as was noted in a number of cases which have been reported. When the cyst is of very large size nearly all of the abdominal organs suffer by compression, and both digestion and absorption are impaired by mechanical pressure. The diaphragm being at the same time pushed upward, the heart and lungs are displaced in the same direction, and embarrassment of circulation and respiration follows as a necessary sequence. Like any other benign abdominal tumor, the cyst proves dangerous to life by interfering mechanically with the functions of more important organs. The second source of danger is rupture of the cyst and escape of its contents into adjacent organs, an accident which may be followed by immediate death from hæmorrhage, or the life of the patient is placed in jeopardy by suppurative inflammation in the interior of the cyst, or by peritonitis in case the contents have escaped into the peritoneal cavity. In Pepper's[74] case the immediate cause of death was hæmorrhage consequent upon rupture of the cyst into the stomach. At the post-mortem examination a large quantity of blood was found in the stomach and intestines, which had entered through an opening about one-half inch in diameter, close to the proximal termination of the ductus communis. A probe passed through this opening directly entered a cyst in the head of the pancreas. A communication with any portion of the gastro-intestinal tract would almost of necessity lead to infection and suppurative inflammation in the interior of the cyst, which, under certain circumstances, might lead to a fatal termination from septicæmia or extension of inflammation to adjacent organs. The prognosis may be said to depend: 1, On the nature and cause of obstruction; 2, on the size of the cyst; 3, on the absence or presence of complications.

Treatment.—In the treatment of a pancreatic cyst the indications are the same as in the treatment of any other kind of retention-cyst, viz., 1, Extirpation of the cyst; 2, evacuation of its contents and obliteration of the cyst.

The brilliant result obtained by Dr. Bozeman is well calculated to stimulate others to follow his example. But the uniformly fatal result attending this procedure in the other cases is a potent argument in favor of incision and drainage—a method of treatment which has been found both safe and efficient. Extirpation should be resorted to only in cases in which portions of the cyst-wall have become the seat of malignant disease; likewise in cases where life is threatened by hæmorrhage into a cyst from the rupture of vessels lining its interior, and which cannot be controlled by simpler and less hazardous measures. Extirpation of the cyst would guard most effectually against the formation of a permanent pancreatic fistula; but, on account of the deep location of the pancreas, shortness or absence of a pedicle, and the many obstacles thrown in the way of the operator by adjacent organs, the procedure becomes one surrounded by innumerable difficulties, and, in the present state of our science, is of doubtful propriety. Simple evacuation of the contents of the cyst by means of the aspirator offers two principal objections against its adoption in the treatment of cysts of the pancreas: 1, Escape of the cyst-contents into the peritoneal cavity; 2, reaccumulation of the secretion.

Reasoning from analogy, we should naturally expect that when pancreatic juice is brought in contact with the peritoneum, it would produce a destructive effect upon it by its digestive properties, or it might even be followed by diffuse peritonitis. In opposition to this assumption, it is affirmed that in experiments on the pancreas it happens quite frequently that pancreatic juice escapes into the abdominal cavity, from the cannula introduced into the pancreatic duct, without being followed by any bad results. Concerning this point Heidenhain says: "The animals do not suffer from this circumstance, as the duct is regenerated in spite of the wounded surface being bathed in the secretion." Nevertheless it is difficult to explain why the wounded and suppurating tissues do not undergo digestion by the pancreatic juice. The efficacy of the albumin-ferment is destroyed in some way I presume, probably by being changed into zymogen, the living tissues having the same effect on the juice as that observed by Podolinski after treating the pancreatic juice with pulverized zinc or yeast-ferment. Although small quantities of pancreatic juice may escape into the peritoneal cavity of an animal without any serious consequences, we have no evidence to show that the peritoneal cavity in man is possessed of the same degree of immunity against such an accident, and it would not be prudent to expose a patient to such risk until more light is thrown on this subject by further observation and experiment. At the same time we must not forget that pure pancreatic juice is found only in small cysts, as the contents of large cysts have undergone various transformations, and are mixed with different accidental products which might prove an additional source of danger in producing peritonitis. In all of the cases in which a pancreatic fistula was established, the artificial opening continued to discharge the secretion for a variable period of time, and in two cases the discharge had not ceased at the time the report was made, and hence reaccumulation would have been inevitable in case the fluid had been removed by aspiration. For these reasons the treatment by aspiration should be limited to cysts of moderate size, and to those cases in which adhesions have formed between the cyst and the anterior wall of the abdomen. In cases presenting these favorable conditions, aspiration deserves a trial, and may be repeated as often as required, or until symptoms arise which call for more radical measures. The needle should always be thoroughly disinfected by passing it through the flame of a spirit-lamp, and by dipping it in a five per cent. solution of carbolic acid. The puncture is made obliquely, so as to prevent the formation of a fistulous opening. The fluid should be withdrawn slowly and the cyst emptied as completely as possible.

After the operation gentle pressure should be made over the cyst, by applying a compress and elastic bandage. The safest and at the same time the most efficient treatment, consists in establishing an external pancreatic fistula. The operation which accomplishes this purpose most safely, and in the shortest time, consists in exposing the cyst by an incision and stitching its walls to the margins of the wound. The same aseptic precautions must be observed before, during, and after the operation, as in any other abdominal operation. The stomach being generally pushed forward, upward, and toward the right by the cyst, it is advisable to empty this organ completely, as a preliminary measure, by abstinence from food and by the use of the siphon irrigator. Except in my case the incision was always made in the linea alba. It seems to me that the incision should always be made over the most prominent part of the tumor, and as nearly as possible over the seat of obstruction. In following this rule we select the place where we are most apt to find adhesions; at the same time we establish the straightest and most direct route to the primary origin of the cyst. An incision through the linea alba, or parallel with the costal arch, will afford the easiest access with a minimum risk of injury to important parts. The external incision should be at least four inches in length, while the peritoneum should be opened only to the extent of two inches, for the purpose of making an exploratory examination, the opening to be enlarged as occasion may require. If adhesions are found between the cyst and the omentum, and between the omentum and the parietal peritoneum, the cyst is punctured with an exploratory needle, and, if the diagnosis is corroborated, the operation is finished by incising and draining the cyst. If no adhesions are found between the omentum and peritoneum, the former is incised so as to expose the cyst-wall, when the following plans may be pursued: The parietal peritoneum is first stitched to the skin with catgut; the margins of the omental wound are then pushed back under the abdominal walls so as to expose the cyst freely, the wound is packed from the bottom with iodoform gauze, and an antiseptic dressing is applied and retained for six or eight days, or until adhesions have formed between the cyst and the margins of the wound. When these adhesions have effectually shut off the peritoneal cavity, the cyst is incised and drained.

Suturing of the cyst-wall to the margins of the wound as a preliminary operation should never be resorted to, as on account of thinness of the cyst-wall there is danger of escape of fluid into the peritoneal cavity from the punctures made by the needle, an occurrence which the procedure was intended to obviate. With proper care, however, the operation can be completed at once. The cyst-wall is grasped with two many-toothed forceps, and drawn forward so as to bring it in accurate and close contact with the margins of the wound, when the fluid is removed with an aspirator or trocar, with the same care that is used in emptying an ovarian cyst. As the cyst becomes empty it is pulled through the wound, thus obviating any further danger of escape of fluid into the peritoneal cavity. When the cyst is nearly empty it is freely incised and sutured to the peritoneal lining of the abdominal wound. The drainage-tube should be fully three-quarters of an inch in diameter, and must reach from the bottom of the cyst to the surface of the wound. After emptying the cyst completely by compression, and placing the patient on his side, a large Lister dressing is applied for the purpose of guarding against infection and to absorb the secretions. Frequent change of dressing may be required on account of copious escape of pancreatic secretion. Past experience would dictate the advisability of protecting the skin against the digestive action of the pancreatic juice by applying carbolated oil freely. The antiseptic dressing should not be abandoned until the peritoneal cavity has become completely closed by firm adhesions, and the opening into the cyst has been reduced to a fistulous tract. The drainage-tube is shortened from time to time as the depth of the fistulous opening is diminished by obliteration of the cyst from the bottom of the tract. The speedy obliteration of the cyst will depend on the continuance, abatement, or removal of the obstructing cause, or on the condition of the gland-tissue distal to the seat of obstruction. If the stricture in the common duct of the pancreas is complete and of a permanent character, the obstruction will continue, and, if healthy gland-tissue remains on the distal side, the fistula will continue to discharge pancreatic juice. If the inflammation which caused the obliteration of the duct subsides, and the passage again becomes permeable, the natural outlet will be again established and the artificial duct will become obliterated. If an impacted calculus has caused the retention, and the fistula continues to discharge, a careful examination should be made to detect the calculus, and, if found, an effort should be made to remove it through the fistulous opening. If the obstruction has become permanent and the gland-tissue on the distal side has become destroyed, either by the cause or causes which produced the obstruction, or by the intra-cystic pressure, that portion of the organ has been deprived of its functional capacity, and, as no pancreatic juice is secreted, definitive obliteration of the cyst and permanent closure of the fistulous tract will take place in a comparatively short time.

Tumors of the Pancreas.—1. *Hypertrophy.*—Störck[*] mentions a case of intestinal obstruction caused by hypertrophy of the pancreas.

Case 1. A man, forty-eight years of age, previously in good health, had felt a sensation of weight and distress after meals, for more than six months. The flatulence also caused distress, and was relieved at times by the drinking of large quantities of water. Bowels constipated. The symptoms of obstruction developed gradually, but finally became so severe that nothing was retained on the stomach. After obstruction had become complete the patient fell into a state of collapse and died two days later. At the autopsy no signs of inflammation or of effusion into the peritoneal cavity could be found. The head of the pancreas, which was enlarged to the size of an orange, had so completely compressed the duodenum that its lumen would only permit the passage of a goose-quill. The pyloric portion of the stomach was enormously dilated, so that this pouch resembled a kind of lesser stomach. The pancreas was softer, more succulent, and fleshier than normal, but not at all indurated.

Remarks.—As no microscopical examination of the tumor was made, we are unable to classify this case, but considerable doubt must remain whether it was a case of tumor or one of simple hyperplasia of the gland. The age of the patient and the effect of the tumor upon the duodenum make it quite probable that it was not a case of hypertrophy, but rather of carcinoma or sarcoma. The case illustrates the fact that tumors of the pancreas, when they occupy the head of that organ, are liable to produce intestinal obstruction by compression.

2. *Sarcoma.*—Of the malignant tumors of the pancreas, carcinoma is of much greater frequency than sarcoma. Only a very few cases of primary sarcoma of the pancreas are on record.

Case 1. Mayo[*] mentions a case of primary sarcoma of the pancreas, with secondary invasion of the stomach, that came under his care. The patient, a man aged thirty-five, died after an obscure illness which lasted eight months, during which time it was impossible to locate the disease. He dated his illness back to a febrile attack, which left him in a debilitated condition; and from that time he was liable to dyspeptic symptoms, with variable appetite and an undefined feeling of uneasiness in the epigastric region. A high degree of anæmia was a conspicuous symptom during life. Although the appetite remained good, and digestion did not appear to be very much impaired, emaciation progressed rapidly. On inspection all the internal parts were found extremely pale and void of blood; the heart was healthy, but nearly empty. The pylorus was thickened and firmer than usual, and had contracted adhesions to the pancreas. The pancreas was considerably enlarged and of a nearly cartilaginous hardness, except some spots, which were soft, and presented the appearance of medullary sarcoma. No disease could be detected in any other part of the body.

Case 2. Lépine and Cornil[77] examined the body of a man, sixty-two years of age, who had been sick for eleven months, and had suffered from obstinate vomiting for seven months. The head of the pancreas was found very much enlarged; the remaining portion of it was normal. The small curvature of the stomach was adherent to the tumor, the pyloric orifice thickened and its lumen narrowed. The adhesions involved also the liver, diaphragm, and lower surface of the lung. White metastatic nodules were found in both kidneys. Under the microscope, sections of the tumor revealed a sarcomatous structure.

Remarks. In the two cases related here, we have the principal types of the clinical behavior of sarcomatous tumors. In the first case the disease involved almost the entire organ, having given rise to extensive local destruction, without metastasis; in the second case the disease was limited locally to the head of the pancreas, while it had extended early by contiguity to adjacent organs and by metastasis to distant organs.

Friedreich[78] claims that at present we are acquainted with only a single reliable case of primary sarcoma of the pancreas. It is described by Paulicki, and was found to be of the small-celled variety; it was taken from the body of a young man who had died of pulmonary and intestinal phthisis. It had not given rise to any noticeable symptoms during life.

3. *Carcinoma.*—It is claimed by some pathologists that primary cancer of the pancreas is an exceedingly rare affection, and that in the majority of cases in which this organ is the seat of lesion, it occurs as a secondary affection, having reached it by extension from an adjacent organ, especially from the pyloric extremity of the stomach. While this may be true in many cases, quite a number of specimens have been examined in which the disease occurred here as a primary affection. Suche[79] appears to have examined a specimen which affords a good illustration of primary cancer of the body of the pancreas. The middle of the gland was converted into a hard, irregular, nodulated mass, the size of a fist, resting directly upon the aorta, which imparted to it pulsation during life. When cut into, the tumor grated under the knife, and the cut surfaces presented a laminated appearance. The substance of the tumor was traversed by numerous large veins; both extremities of the pancreas were healthy, and no secondary nodules could be found in any portion of the body. A primary cancer of the pancreas is also described by Schupmann,[80] where the tumor had formed adhesions with the spleen, while the liver contained a number of metastatic deposits. The terminal extremity of the pancreatic duct contained a cylindrical calculus, with a number of arborescent projections, which corresponded to the contributory ducts. In another case, reported by Récamier,[81] the cancerous tumor, which involved the tail of the pancreas, was connected with the left kidney and compressed the ureter. The right half of the pancreas was healthy, the diseased portion gray, hard, and lardaceous. The pelvis of the left kidney, in consequence of the compression of the ureter, was hydro-nephrotic. The remaining organs were healthy.

Bright,[82] in 1832, reported a number of cases of primary carcinoma of the pancreas, with a special view of illustrating the effect which disease of this organ would have upon the digestion of fat. In three out of eight cases he noticed fatty diarrhœa, and he was inclined to the belief that this symptom, when present, is almost pathognomonic of the existence of disease of the pancreas.

In all cases the fatty diarrhœa was associated with jaundice. The following post-mortem account (p. 17) leaves no doubt that the disease was primarily limited to the pancreas: "The cause of the pressure on the bile-ducts was immediately obvious; for, on placing the hand near the pylorus, a hard lump, of the size of a common egg, was easily felt, and was soon discovered to be the head of the pancreas itself, and not the glands surrounding that part, forming a yellow mass like the boiled udder of a cow, almost cartilaginous in hardness. Its texture was uniformly hard and unyielding, and the whole pancreas was of a similar character, but less in degree. The head of the pancreas was firmly and inseparably glued to the duodenum, and the hardness very nearly surrounded the viscus."

As undoubted instances of primary cancer of the pancreas, we must mention the published cases of Muehry,[83] Albers,[84] Haldauer,[85] Webb,[86] Gross,[87] Luithlen,[88] Roberts,[89] Wagner,[90] Bowditch,[91] Davidsohn,[92] Williams,[93] and Frerichs,[94] as referred to by Friedreich.[95]

According to Da Costa,[96] cancer of the pancreas is more frequent in the male than in the female, and in preference attacks individuals over forty years of age. It usually appears as a firm tumor or scirrhus, with a well-developed connective-tissue reticulum. Other varieties of carcinoma have been described. Thus, Wagner observed a cylindrical-celled epithelioma, and Lücke and Klebs have each met with the colloid variety. The primary starting-point is usually in the head of the organ, whence it extends in all directions. By extension within, it successfully invades the body and tail of the organ, until the whole gland is involved, when it forms a nodulated spherical tumor. The extension of the growth in an opposite direction soon reaches the duodenum, where it produces a narrowing or complete stenosis of that portion of the intestinal canal. A case of this kind is related by Hœlscher, in which the duodenum was constricted to such an extent that it was entirely impermeable, and the patient suffered for several days from symptoms of intestinal obstruction. While cancer of the stomach is liable to extend to the pancreas, the reverse is not frequently observed. When the carcinoma develops primarily in the pancreatic ducts, it belongs to a variety called cylindrical-celled epithelioma. The lymphatic glands in the vicinity of the pancreas are invariably affected during the latter stages of the disease.

Symptoms and Diagnosis. Stearrhœa is an important but not pathognomonic symptom of cancer of the pancreas. It is attributed to an absence of the pancreatic juice in the intestinal canal, caused either by obstruction in the duct or by suspension of the physiological function of the organ in consequence of the neoplastic infiltration. Epigastric pain is an early and important symptom, and is the result of compression of the cœliac plexus by the tumor. The pain often assumes a neuralgic character, and is usually not aggravated after taking food. Vomiting is a frequent symptom, and the matter ejected is generally a watery fluid, sometimes stained with bile. Constipation is an almost constant symptom. Progressive emaciation and anæmia attend malignant disease in any locality, but are unusually well-marked in cancer of the pancreas. When the disease extends toward the duodenum, jaundice occurs from stenosis of the bile-ducts by compression or direct invasion by the neoplasm. Bruen has called attention to some forty cases of jaundice due to primary carcinoma of the head of the pancreas, lately reported by another observer, from which it is demonstrated that jaundice is an invariable symptom of primary scirrhus of the head of the pancreas, while it is uncommon when the disease is secondary, or affects the body or tail of the organ. The most reliable evidence is the appearance of a tumor in the epigastrium, behind the stomach. The difficulty of examining the pancreas during health by palpation is appreciated when a physical examination is to be relied upon in locating tumors in this locality. The normal pancreas can be felt only under the most favorable conditions through a thin and relaxed abdominal wall, but in determining its relative size this method of examination affords but little reliable information. A cancer of the pancreas, when it can be felt by palpation, appears in the epigastrium as a hard, immovable, or only slightly movable tumor, which is evidently deeply seated in the abdominal cavity. Under favorable conditions the connections of such a tumor with the pancreas can sometimes be demonstrated during life, but a positive diagnosis becomes impossible, when, as in most of the cases hitherto recorded, it constitutes merely a part of a general tumefaction of the abdomen. As the tumor is in such close proximity to

the abdominal aorta, the pulsations of this vessel are imparted to the tumor, and a bruit may even be heard over the compressed vessel; but, in contradistinction to an aneurism, the pulsation is felt in only one direction, and the bruit disappears when the patient is placed in the knee-elbow position, as the tumor is removed from the vessel by the force of gravitation.

That the tumor cannot always be felt is evident from the statement made by Da Costa that he recognized it in only 13 out of 137 cases that he reported, and Bigsby, in an analysis of 15 cases, alludes to its being recognized in only 4.

From what has been said, it will be seen how uncertain the symptoms are in the diagnosis of cancer of the pancreas. A satisfactory conclusion can be reached only after a careful consideration of the history of the case, combined with a systematic elucidation of all the symptoms presented, and more particularly by resorting to the advantages to be derived from a systematic and careful study by exclusion.

Treatment. A positive diagnosis of malignant disease of the pancreas is only possible after the tumor has attained sufficient size to be recognized by palpation, consequently too late for a radical extirpation. When the disease has advanced to this stage, it has already involved the greater portion of the gland, and, as a rule, has invaded important adjacent organs. Another important element in the surgical treatment of cancer of the pancreas consists in the fact that the disease, as a rule, develops primarily in the head of the organ, a location which, in itself, precludes the propriety of an operation. The most favorable conditions for extirpation are presented if the disease is primarily located in the tail of the pancreas, and has not passed beyond the limits of the capsule of the gland. In such a case, excision of the splenic extremity of the pancreas would offer a fair prospect of a permanent cure without endangering, as a remote consequence, the process of digestion, since a sufficient amount of secreting structure would remain in connection with the intestine to maintain pancreatic digestion.

Billroth, in two instances, made a partial resection of the pancreas in removing carcinomatous tumors of adjacent organs. In one case he removed a portion of the head of the pancreas with a cancer of the pylorus, and in another case he removed the tail of the pancreas with a sarcomatous spleen. Both patients recovered from the immediate effects of the operation. In the case of partial excision of the head of the pancreas it is to be assumed that the duct was not injured, that the organ continued to secrete, and that the pancreatic juice was discharged into the duodenum through the uninjured duct. In operating upon the head of the pancreas for malignant disease which has extended to it from an adjacent organ, it is essential to preserve the continuity of the duct, so as to prevent physiological detachment of the remaining portion of the gland, an accident which would be followed by degeneration and complete atrophy, consequently suspension of pancreatic digestion. If an operation is performed for cancer of an adjacent organ, and the disease has extended to the splenic extremity of the gland, the operation should not be completed without removing a sufficient portion of the pancreas to guard against a local recurrence of the disease in this organ. As in cases of partial excision of the pancreas for other lesions, the pancreas should be ligated before it is divided, so as to prevent troublesome hæmorrhage, and at the same time guard against extravasation of pancreatic juice into the peritoneal cavity.

Tuberculosis of the Pancreas.—Primary tuberculosis of the pancreas is an exceedingly rare affection; indeed, some pathologists, among them Louis and Lebert, doubt its primary origin in this organ. Cruveilhier only mentions tubercular degeneration of the lymphatic glands upon the surface of the pancreas. In diffuse miliary tuberculosis of the abdominal organs Klebs could find no nodules in the substance of the pancreas on microscopical examination. But in such a condition the gland is often found in a state of parenchymatous degeneration which has been incorrectly interpreted as the first stage of tuberculosis by Ancelet.

When the lymphatic glands around the pancreas have undergone cheesy degeneration, we sometimes find similar deposits in the pancreas, which, however, may be cheesy lymphatic glands in the substance of the pancreas itself. Hartmann mentions a case in which the pancreas had disappeared completely, and its place was occupied by a cheesy mass. Although the pancreas is not disposed to tuberculosis, we have reliable information that in a number of cases this gland was the primary seat of the process.

Case 1. Reported by Aran.[7] The patient was a woman, twenty-five years of age, who died of a lingering disease. She had been sick for a year, during which time she felt exceedingly weak, had frequent attacks of vomiting, and the skin became deeply bronzed, and in some places almost black. The pain, which was severe at times, was referred to the epigastrium. The necropsy showed a tubercular deposit in the tail of the pancreas the size of a hen's egg, surrounded by a zone of miliary deposits in the substance of the gland. Miliary tubercles were also found in the spleen.

Case 2. Mayo[98] describes a case in which we have reason to believe that the process commenced primarily in the pancreas. The patient was an inmate of Middlesex Hospital, and was under the care of Dr. Wilson. He was thirty-eight years of age and had been ill for sixteen weeks, during the last seven of which he had been confined to his bed. The first symptoms were pain in the abdomen, extending along the right hypochondrium to the spine. Twenty-eight days before death he became jaundiced, the stools were white, and the urine was high-colored; for some time he could lie on the right side only, and was often obliged to sit upright to draw breath. A large abdominal tumor had been felt immediately above the umbilicus some time before death, and the right arm and side of the neck had become œdematous. Autopsy: Serous effusion into the right pleural cavity. The gall-bladder was distended to a great size, so as to contain eight ounces of fluid. The distention arose from an enlargement of the pancreas, the head of which formed an irregular sphere four inches in diameter, which had compressed the gall-duct; the rest of the gland was likewise enlarged. In parts it presented its natural texture and color, at other parts it was infiltrated with tubercular matter, which, at two or three points, had softened and formed thick pus. A few lymphatic glands, the thymus gland, and the kidneys, appeared to be secondarily involved.

Remarks.—Although in both of these cases the symptoms during life pointed to disease of the pancreas, a sufficiently positive diagnosis to warrant a laparotomy could have been made only after a palpable tumor had appeared, and by this time the disease would have already passed beyond reach by reason of the appearance of miliary deposits in other organs, an occurrence which would preclude the justifiability of any operative interference. Should abdominal section be performed in a case of tubercular peritonitis, and should such a condition of the pancreas be found as in Aran's case, it would be proper to extirpate the terminal end of the gland inclusive of the tubercular abscess.

In Wilson's case the tubercular deposit in the pancreas gave rise to a large abdominal tumor, due partly to the distended gall-bladder, and as such a condition might present itself to the surgeon in these days of diagnostic laparotomy, it might be advisable, and to the advantage of the patient, to establish an external pancreatic fistula instead of closing the wound. Such a course would enable the surgeon to remove the cheesy material, disinfect the abscess cavity, and treat its interior with iodoform, all of which, done under antiseptic precautions, would tend to modify favorably the local process.

The removal of compression of the bile-duct by the same procedure would also tend to re-establish the interrupted communication between the bile-ducts and the duodenum by removing the cause of the stenosis.

Lipomatosis of the Pancreas.—Lipomatosis, or fatty

infiltration of the pancreas, is a pathological condition of this organ which is characterized by a transformation of the interacinous connective tissue into fat, in contradistinction to fatty degeneration of the cells of the parenchyma, which sometimes occurs as an independent affection. In cases of fatty infiltration the shape and size of the pancreas may remain normal, but the secreting structures themselves may have completely disappeared by pressure-atrophy. This disease is of little interest to the surgeon, except that it may serve as a predisposing cause of interstitial hæmorrhage, in which connection it has already received mention; it is here again alluded to as a separate affection to demonstrate that gradual atrophy of the pancreas, even to the extent of complete disappearance of the glandular structures, may occur without causing serious impairment of the digestion. Rokitansky[99] has found this condition of the pancreas generally as part and parcel of a general obesity, especially in intemperate persons, together with fatty liver, heart, and omentum. In the three cases of pancreatic apoplexy described by Zenker, the fatty infiltration of the pancreas was only one of the many evidences of a general malnutrition of the tissues. In some of these cases the patients exhibited no symptoms during life indicating the absence of the pancreatic secretion, and yet, on making the post-mortem examinations, complete destruction of the glandular structure was found.

Litten[100] has reported three cases of complete atrophy of the pancreas in which, during life, no symptom of pancreatic disease, such as fatty stools, salivation, lipuria, bronzed skin, cœliac neuralgia, etc., was observed. In two cases the atrophy was due to pressure, and in one instance it was caused by primary cancer of the pancreas.

In other cases the suspension of the pancreatic function by fatty degeneration of the organ produces well-marked symptoms during life, and may even result in death. Such a case is reported by Lépine and Cornil.[101] The patient was a drunkard, fifty-seven years of age. For six months he had been suffering from indigestion, marked loss of weight, diarrhœa alternating with constipation, but had no fever and no vomiting. For two months his body had been covered with an eruption, and his feet became œdematous. At the autopsy the pancreas was found normal in size and shape, but the parenchyma of the gland had entirely disappeared, and its place was

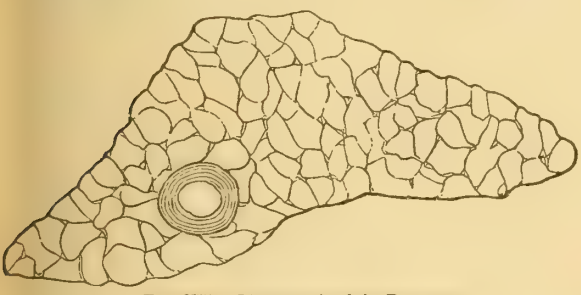

Fig. 2750.—Lipomatosis of the Pancreas.

occupied by adipose tissue (Fig. 2750). The pancreatic ducts were filled with a viscid whitish fluid and small concretions. No other cause of death could be found in any of the remaining organs. Clinical observation appears to confirm the results obtained by experiments on animals, that in some instances complete gradual atrophy of the pancreas is compatible with normal digestion, while, in other cases, the suspension of the pancreatic secretion is followed by serious disturbance of digestion, marasmus, and death from inanition.

The only plausible explanation of the different effects of the same cause can be found in the supposition that in some individuals the compensating function of vicarious organs maintains normal digestion, while in others no such compensating action is established.

Lithiasis of the Pancreatic Ducts.—Concretions of carbonate and phosphate of lime are frequently found in the pancreatic ducts. They are usually multiple, small, whitish, smooth, or of rough and irregular shape. Calculi in this locality have been found which measured more than an inch in diameter. In Schupmann's case, the calculus weighed two hundred grains and measured one and a half Paris inch in length, and from five to six Paris lines in diameter; it had a crystalline surface, with processes running into smaller ducts. It was found in the left extremity of Wirsung's duct.

Sometimes the concretions of calcium phosphate and carbonate exist in cases of incrustation of the mucous lining of the ducts. According to Collard de Martigny, the calculous concretion is sometimes composed of phosphate of lime alone. The calculi in this locality are usually solid formations of fine, granular structure, with somewhat rough surfaces, and very often covered with sharp points of projection. In some specimens the stone presents numerous branches which correspond to smaller pancreatic ducts. The irritation incident to the presence of a calculus in the pancreatic duct is followed by consecutive pathological changes in the duct and glandular tissue of the organ itself. The substance of the organ in the immediate vicinity of the stone becomes the seat of interstitial inflammation, followed by atrophy and sclerosis; the cicatrical tissue produced by this change causes contraction, an occurrence which may still further aggravate the obstruction. In some instances this inflammatory process does not remain localized, but extends over the entire gland, as in the cases observed by Engel, Elliotson, and Curnow. In some cases the concretion gives rise to suppuration, as in Portal's case. His patient had died suddenly, with symptoms of aneurism of the aorta, and at the autopsy an abscess was found in the head of the pancreas which contained a number of biliary and pancreatic calculi. In Fauconneau-Dufresne's case, as quoted by Ancelet, the left half of the pancreas contained a number of abscesses, one of which had perforated into the stomach. The pus contained numerous concretions, varying in size from that of a pin's head to that of a bean. Salmade observed a case of lithiasis, complicated with abscess of the pancreas, in which the swelling compressed the underlying aorta to such an extent that death was produced by the rupturing of a vessel from over-distention on the proximal side of the obstruction.

Mr. Moore[102] presented to the Pathological Society of London the pancreas of a man, aged forty-three, who died in St. Bartholomew's Hospital of an attack of pleurisy following gouty symptoms. The main duct of the organ was dilated, and contained a calculus of irregular shape, around which was a large abscess in the head of the organ. This abscess pressed upon the orifice of the bile-duct sufficiently to produce great distention of the gall-bladder. A number of cases of cyst of the pancreas have been reported in connection with a calculus in the duct on the proximal side of the cyst, and in which the dilatation of the duct was attributed to obstruction due to the presence of the foreign body in its lumen. Complete stenosis of the pancreatic duct, due to intrinsic or extrinsic causes, is always followed by parenchymatous degeneration of the glandular tissue on the peripheral side of the seat of the obstruction, which necessarily arrests the physiological function in that portion of the organ; hence we are unable to explain the retention of the secretion from this cause, unless impaction of the calculus takes place suddenly. Again, assuming this to be the case, we know that healthy pancreatic tissue will remove its own secretion by absorption in case of sudden stenosis or obstruction of the duct. We are therefore forced to explain the occurrence of a pancreatic cyst in the course of gradual or sudden obstruction of the ducts by a calculus, or cicatricial or malignant stenosis, to parenchymatous changes in the peripheral portion of the gland rather than to the obstruction. This argument, of course, applies only to the so-called retention-cyst. Simple, uncomplicated obstruction of the duct may give rise to an accumulation of pathological products which, under no circumstances, is amenable to removal by absorption. The former assertion is well illustrated by the specimen referred to above which Norman Moore[103] ex-

lobules (Pathological Society of London, where stood great dilatation of the common pancreatic duct throughout its entire length. Near the ampulla the duct was obstructed by a small calculus of irregular shape. The whole gland was hard, and to the naked eye showed a condition of advanced connective-tissue hyperplasia. The papilla in the duodenum was enlarged, and the hard-ened tissue of the pancreas constricted the bile-duct so as to cause complete obstruction. The liver showed secondary changes due to the stasis of bile. A microscopical examination of the specimen showed it to be a case of primary cirrhosis of the pancreas, only a small number of acini remaining in a healthy condition (Fig. 2751).

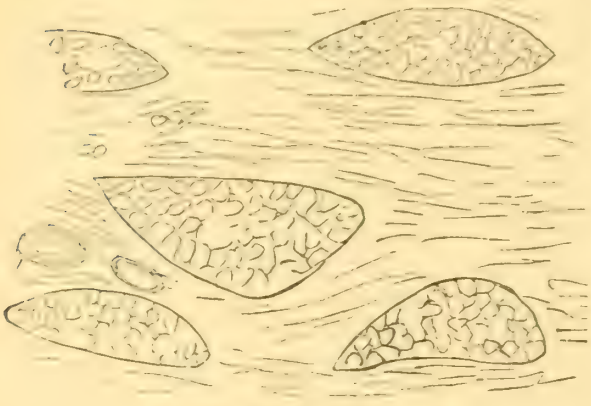

Fig. 2751. —Cirrhosis of the Pancreas.

In this case the cirrhotic change in the organ was undoubtedly produced in the same manner as that following constriction of the duct as practised in the experiments on animals, the first link in the chain of pathological changes being the mechanical obstruction of the duct by calculus.

Symptoms and Diagnosis.—A positive diagnosis of pancreatic lithiasis during life is impossible. Calculi and concretions have been found at post-mortem examination in persons who, during life, did not suffer from any symptoms indicating the existence of such conditions. Pain, fatty stools, hæmatemesis, and diabetes, are symptoms sometimes associated with this lesion of the pancreas, but when present they point rather to the existence of a consecutive lesion of the substance of the gland produced by the calculus than to the presence of the calculus itself. If the calculus be arrested at the outlet of Wirsung's duct, it may, at the same time, obstruct the exit of the bile by compressing the ductus choledochus, and so cause jaundice. But the same effect can also be produced by cirrhosis of the head of the pancreas, with or without the presence of a calculus in the pancreatic duct. Mr. Morris claims that he has seen cases of pancreatic stone colic, but in such cases it would be impossible to differentiate between the passage of a biliary and that of a pancreatic calculus along their respective ducts, as a biliary calculus may obstruct the common pancreatic duct, and *vice versa*.

Treatment.—As the diagnosis of a calculus of the pancreas, *intra vitam*, is impossible, the surgical treatment must be limited to the management of some of its consecutive lesions—cysts, abscess, and retention of bile.

The treatment of cystic disease and abscess of the pancreas has been considered under the respective headings, and I will only add that when these conditions have been caused by an impacted calculus, an effort should be made to recognize the primary cause, and, if possible, to remove it. As the surgical treatment of retention of bile, due to the mechanical obstruction of the biliary passages, is now receiving much attention on the part of surgeons, it is well, in this connection, to call attention to impaction of a pancreatic calculus in the duodenal portion of the pancreatic duct as an occasional cause of obstinate jaundice. If, in a case of this kind, abdominal section should reveal the true nature of the obstruction, an effort should be made at the time to force the calculus into the duodenum by taxis; and if this cannot be accomplished, the propriety of cutting for the stone should be carefully considered. As an impacted calculus in this locality not only endangers the life of the patient by cholæmia but may also destroy life suddenly by perforation into the peritoneal cavity it would be not only justifiable but good treatment, provided a fairly positive diagnosis has been made by means of diagnostital laparotomy. The greatest danger attending such a procedure would be extravasation of bile into the peritoneal cavity. This accident should be guarded against by removing the retained bile by aspirating the dilated bile-ducts as a preliminary necessity. After extraction of the stone the incision in the duct should be accurately closed with fine silk sutures. The secretion of bile and pancreatic juice should be reduced to a minimum after the operation by keeping the digestive organs in a condition of absolute physiological rest during the time required for the healing of the visceral wound. *N. Senn.*

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PANOPHTHALMITIS. General suppurative ophthalmia; a purulent inflammation of the contents of the eyeball resulting from the extension, by infiltration, of a suppurative focus in one membrane or tissue to all the others.

With our present knowledge of the causes of suppuration this is believed to be, in all cases, of septic origin, the septic material being introduced by means of a traumatism which may be inflicted intentionally, as in a cutting operation, or accidentally by a foreign body penetrating from without and lacerating some part of the globe. The cornea, being the most exposed, is the part most frequently injured. If the foreign body be driven into the globe the opportunity for carrying septic material in with it is vastly increased, and suppurative inflammation is more likely to follow, even if it be afterward removed. Exceptionally the disease is metastatic, the original focus of inflammation (suppuration) being quite distinct from the eye itself; it is then pyæmic in character, and begins usually as suppurative choroiditis.

In cases of wounds of the cornea without penetration of a foreign body into its deeper parts, whether lacerated from a blow or following the clean cut of an operation properly performed, the first evidence of the trouble to follow is a grayish line along the edges of the wound, rapidly growing yellowish in color, indicating a purulent infiltration at the cut surfaces, which extends rapidly (in the course of a few hours) to the rest of the cornea; the wound gapes and, on opening the lids, pus is seen exuding from its edges. At the same time, or occasionally preceding this, there is œdema of the edges of the lids, which soon extends to the loose cellular tissue, the lids thereby becoming livid and immensely tumefied. The ocular conjunctiva participates in the inflammation, becomes reddened and œdematous, projecting almost like a bladder from between the distended lids; the cornea itself is almost buried in the swollen conjunctiva which overlaps it, so that it appears as if buried in a pit below the surface (*chemosis*). During this time the infiltration of the cornea extends, the tissue becomes softened, breaks down, and pus which has formed in the interior from the subjacent iris and beyond exudes through the wound. In lieu, the limits of the wound become unrecognizable in the purulent mass which occupies the place of the cornea, now become staphylomatous by the pressure of the suppurating contents of the globe.

In the beginning there may not be much pain, and this is often particularly noticeable in cases following cataract extraction in feeble old persons, which may run on to complete purulent infiltration and breaking down of the cornea without pain. With the swelling of the eyelids, the infiltration of the ocular conjunctiva and orbital tissues, and the involvement of the deeper tissues, especially the iris, the pain, however, becomes severe, often uncontrollable, except with very large doses of opium. It radiates over the whole distribution of the trigeminus nerve of that side, though it is usually more severe along the course of the supra- and infra-orbital branches. With the breaking down of the cornea and the escape of the pus through the opened wound there is a relief to the intra-ocular tension, and this, together with the changes which the individual tissues undergo in consequence of their complete disorganization, brings about a subsidence of the pain, which thereafter gradually ceases.

The extrusion of the contents of the globe, brought about by the unresisted pressure of the ocular muscles, causes its collapse. It shrinks greatly, and loses its spheroidal shape, becoming marked by depressions at the insertions of the recti muscles. With the subsidence of the inflammation in the interior of the eye, there being no longer any organized tissue to feed upon, the orbital and palpebral swellings diminish, and the lids become less livid and tense. In due course the ocular conjunctiva clears up, showing the sclera underneath, which gradually reassumes its usual whiteness. The cornea, however, is never restored; it loses entirely its transparency, and is converted into an opaque mass of cicatricial tissue through which is dimly shown the pigment derived from the iris, closely agglutinated to its posterior surface. The dark shimmer occupies, however, but a very small part of the area of the former cornea. The atrophy of the globe is complete. Such is the usual course of a suppurative inflammation of the eye following a more or less extensive wound of the cornea.

In cases in which the wound of the cornea is slight, but in which a foreign body is driven into the eye, whether behind the iris or not, and lodges there, or even if it be removed, the course is often somewhat different. The focus of initial infection is usually the point occupied by the foreign body, and the evidence of a suppurative process being started up is often first suggested by a greenish reflection, seen by oblique illumination or by the ophthalmoscope from a point deep in the fundus of the eye, showing through the still clear pupil. The inflammation of the external parts immediately following the injury has either subsided or there may have been too little to excite alarm; but the vision not being correspondingly restored, an ophthalmoscopic examination reveals an undefined tumor with a greenish reflection in the midst of a somewhat obscure area of inflammatory exudation in the vitreous. This reflection is not unlike in appearance that of a shred of detached retina, which condition may, indeed, coexist as one of the immediate results of the accident. The history of an accident would, of course, indicate the probable nature of the trouble, and the subsequent course of the disease soon proves the object to be a focus of suppuration at the site of the lodgement of the foreign body. This usually soon spreads, tracing its way along the track of the wound, infiltrates the surrounding tissues more or less rapidly, and involves all the contents of the globe. The vitreous liquifies, then suppurates, the retina becomes detached by effusion between it and the choroid, and sooner or later all the tissues become fused into a disorganized mass in which only the remnants of former membranes and tissues can be recognized. This disorganization is shown by the softening of the globe on pressure, and sometimes before the pus comes to the surface, by the appearance of the sulci marking the insertions of the recti muscles.

When the suppuration, after travelling along the track of the wound, has reached the cornea, its progress is usually more rapid. The cornea sometimes breaks down *en masse*, the whole membrane becoming rapidly converted into a pultaceous mass, or the old wound may gape and allow the contents to escape, the globe subsequently collapsing as above described.

In general, when the pus does not make its appearance in the bottom of the wound for some time after the receipt of the injury, and when the corneal wound has closed up, the progress of the inflammation is slower than in the first-described class of cases, in which the suppurating process begins at the external wound. But it is just as fatal to the integrity of the visual organ, and, as there is in these cases nearly always a persistent source of irritation at the bottom of the wound, the foreign

body being lodged there, the very great additional danger exists of its being followed by that most insidious and uncontrollable form of inflammation in the *other eye* known as sympathetic ophthalmitis (*vide*).

Panophthalmitis occurs sometimes, also, as a result of non-traumatic ulceration of the cornea. When there is perforation into the anterior chamber, with prolapse of the iris, the opportunity is presented for the access of septic micro-organisms into the interior, and the result will be the same as in septic infection following wounds. The course of this disease is properly described in the article on Suppurative Keratitis (vol. ii., p. 297). The termination is of course the same, *i.e.*, phthisis bulbi.

Treatment.—It goes almost without saying that when a panophthalmitis has fairly gotten under way, nothing can be done to save vision; efforts to that end must be made in the initial stage before pus has formed, and the reader is referred to the articles treating of the conditions from which the panophthalmitis results, viz., Suppurative Keratitis (vol. ii., p. 297), Iritis (vol. iv., p. 219), Choroiditis (vol. ii., p. 147), and Injuries of the Eye (vol. ii., p. 795). We have here to do simply with efforts to mitigate the suffering, to shorten the inflammatory process, to conduct it safely to its legitimate end of atrophy of the globe, without the involvement of the surrounding orbital tissues, or of neighboring organs and cavities.

In the beginning, or even toward the height of the inflammation, the application of leeches to the temple (just beyond the orbital margin, to avoid an unsightly ecchymosis of the orbital connective-tissue) will often measurably relieve the pain, and apparently check the progress of the inflammatory action; the number depends mainly upon the degree of inflammation and the robustness of the individual; from two to six or eight are about the limits. Being applied over a bony surface the hæmorrhage is quite under control by pressure, so that the bites may be allowed to bleed unrestrictedly afterward, or until the pulse shows evidence of cardiac failure. Fomentations of hot water, as hot as can be borne, applied to the closed lids, often relieve the pain very decidedly, and these should be kept up day and night, for from fifteen to twenty minutes at a time, at intervals of two or three hours until the pain becomes tolerable. Fomentations are preferable to poultices, continuously applied, being more comfortable because less heavy and cleaner, and because the skin of the eyelids does not become soggy, as occurs when these are applied for any great length of time.

I have never thought that any good was accomplished by laying the eyeball open by incisions carried through the cornea, with the idea of relieving tension. The pain is not from pus being retained within the globe, but is properly from tension of the tissues by interstitial infiltration, and this is not relieved by the incisions; neither have I ever found scarifications of the conjunctiva of any avail. I formerly practised both these procedures, but have given them up entirely, depending upon the fomentations locally and the administration of anodynes internally to relieve the extreme pain, which often threatens to wear the patient out in spite of all our endeavors to relieve.

In view of this extreme and often long-continued suffering (for it is a matter of from ten days to three weeks before the subsidence of the inflammation is sufficient to allow the remission of active treatment), and of the all-important fact that the eye is ruined, the question of enucleation of the globe, to shorten the time of confinement and suffering, presents itself to the mind of every surgeon. In 1863 von Graefe reported two cases of death from meningitis following, and, as he believed, *in consequence of*, the enucleation of eyes in the stage of active suppuration, and since that time German ophthalmologists, at least, have hesitated to practise or advise a procedure threatened by so serious consequences. The independent and radical Mauthner, indeed, says "the ghost of such an accident" has quite prevented him from performing the operation. Surgeons in other countries, not so bound by the traditions of the Berlin school, have been more venturesome, and do not report cause for regretting it. I have enucleated several such eyes, and my patients were relieved of much suffering and saved much time, and never, until this article was under way, have I met with any untoward circumstance. I had, however, recently under my care a somewhat decrepit and prematurely aged man, of sixty-five years, with atheromatous arteries, who developed a panophthalmitis as the result of a lacerated wound of the cornea and prolapsed iris, from a blow with a stick of wood. Enucleation was performed after the orbital tissues had become a good deal swollen, because his decrepit condition seemed to forbid the risk of a long-continued suppurative process. More than usual antiseptic precautions were taken during the operation and in the subsequent treatment, but the patient died in four days from cerebral meningitis, induced by the propagation of the inflammation in the orbital tissues through the optic foramen, along the optic nerve-trunk to the cranial cavity, rendered, I think, exceptionally easy by the sclerosis of the arteries. Vignaux's single fatal case was in a man eighty-one years of age. I am satisfied, therefore, that age adds greatly to the risk of the operation, and while it appears probable that in youth the dangers have been exaggerated, in advanced years the enucleation of an eye which is the seat of active general suppuration is not a safe procedure.

A point of minor importance in the general question of enucleation is the fact that an atrophied stump allows more motion to an artificial eye than is possible after enucleation, when the muscles are all united in a common cicatricial mass, forming a depression at about the centre of the bony orbit. *W. H. Carmalt.*

PANSY (*Viola Tricolor*, U. S. Ph.; *Herba Violæ Tricoloris*, Ph. G.; *Pensée sauvage*, Codex Med.; Heart's-ease). This little plant, so universally admired for its brilliant and beautiful flowers, is a native of Europe, and partially naturalized in the United States. In its primitive or wild form, with small, quite irregular flowers, it is often seen in waste places around old gardens; and it reappears, after a generation or two of neglect or poor cultivation, in any of the magnificently developed florists' varieties. Even the later flowers of plants, which at first produced fancy, hybrid forms, may approach the natural type. The Pharmacopœia directs this wild or natural form as the proper one for medicinal use, and gives the following description of it: "Stem angular and nearly smooth; leaves alternate, petiolate, ovate, or oblong, crenate, with leaf-like, pinnatifid stipules; flowers with an obtuse spur, and the variegated petals longer or shorter than the calyx; inodorous; taste somewhat bitter and acrid."

Composition.—Little, if anything, of value has been found in pansy; a glucoside, *violaquercitrin*, of probably no active properties, and a little *salicylic* acid or something yielding it, are about all. Syrups, decoctions, and other preparations of pansy are occasionally given for the seborrhœas and eczemas of infants, as general "alteratives," and in some renal and vesical troubles, etc. It is simply an inactive and indefinite drug, very little employed in intelligent practice, and deserving of being relegated to the flower-garden, its proper place.

Allied Plants, etc.—This genus contains about a hundred species, natives generally of temperate climates, many of which have lovely and much appreciated flowers. *V. odorata* Linn., the "English Violet," as it is called here, has a blue or purple corolla, often double, and very sweet-scented. It is cultivated extensively for ornament. *V. pedata*, the crow-foot violet of this country, was formerly included in the Pharmacopœia with *V. tricolor* as one of the sources of medicinal violet. Besides these a dozen or more species, blue, lilac, white, and yellow, are well-known spring flowers. *V. odorata* contains a gastric irritant called *violin*, but not completely isolated, which causes vomiting and diarrhœa, and several species have been shown to yield salicylic acid. None of the violets has any special economic value, however, and the other genera of the order are almost devoid of interest, excepting to the botanist.

W. P. Bolles.

PANTICOSA is a thermal station situated on the Spanish side of the Pyrenees, lying at an elevation of 5,570 feet above the level of the sea. There are five springs, named according to their supposed indications, the Fuente del Estomago (stomach), Fuente del Higado (liver), Fuente de los Herpes, Fuente Purgante or Fuente de la Laguna, and Fuente de la Jaqueta (migraine). The temperature of these waters range from 68° to 88° F.

The following is the analysis, made by Dr. Herrera, of two of these springs, calculated in parts per thousand:

	Fuente del Estomago.	Fuente de los Herpes.
Sodium sulphide	0.0435	.....
Calcium sulphide	0.0630	.....
Sodium sulphate	1.2241	1.5504
Sodium chloride	0.0018	0.5550
Magnesium chloride	.....	0.0155
Calcium carbonate	.....	0.0400
Ferrous carbonate	0.9730	.....
Silicic acid	0.0410	0.0385
Glairine	0.6110	.....
Total solids	2.9574	2.1994

The waters are employed in the treatment of a great variety of affections, such as catarrh of the respiratory and digestive apparatus, syphilis, skin diseases, rheumatism, neuralgia, various neuroses, and malarial poisoning. The establishment is said to be one of the best of its kind in Spain. The climate is cold, the winters are long, and the season for guests embraces only the three months of July, August, and September. About a thousand guests visit Panticosa every summer. *T. L. S.*

PAPAW, THE. *Carica Papaya* Linn. (*Papaya Carica* Gaertn.); Order, *Passifloraceæ, Papaeæ.* This interesting plant is a small, quick-growing tree, eighteen or twenty feet in height, of palm-like aspect, with a thick, soft, cylindrical trunk, surmounted by a hemispherical head of large, long-petioled, alternate, palmate leaves. The flowers are rather small, yellowish- or greenish-white, regular, pentamerous, perfect, or polygamous. The fruit, for which it is cultivated, is an edible, melon-shaped, many-seeded berry. All the green parts of the plant—stems, leaves, and unripe fruits—contain a white milky juice in considerable quantity, of bitterish, acrid taste, and remarkable digestive powers. This tree is a native of tropical America, in most parts of which it is also cultivated, and from whence it has been introduced into India and other warm countries. Its fruit has been for a long time an article of food where it can be grown, and the power of its leaves and juice to soften meats has been occasionally utilized in the same localities. Witmack, a number of years ago, experimented with it as with pepsin, and found it to possess very similar powers over fibrin and albumen. Lean meat and coagulated albumen of eggs became quickly dissolved in it at a warm temperature, even without the use of acids, and finally were completely dissolved. It also converts starch solution into dextrin and sugar. Messrs. Wurtz and Bouchat separated from the juice a permanent, white, active powder, which they named *papaïn*, the same probably as that separated by Peckott a short time before and called by him *papayotin*. Papaïn is a stable, white, inodorous, amorphous, nearly tasteless powder, readily dissolving in water and glycerine, and possessing in a greater degree than most pepsins the same solvent power as they, digesting about a thousand times its weight of meat-fibrin. It also peptonizes milk as well as pancreatin or trypsin.

The expensiveness of this substance has prevented any extensive employment, and is likely to do so unless some, as yet not proven, peculiar advantage over pepsin can be shown for it. It has been employed a little for the same purposes as pepsin—to aid imperfect digestion and the solution of diphtheritic membranes. Dose about the same as that of the strongest pepsin.

Allied Plants.—The genus contains about twenty species, several of which are useful.

Allied Drugs.—Pepsin, Pancreatin, Diastose, etc. The juice of the Fig, and probably of some other lactiferous trees, has some digesting power. *W. P. Bolles.*

PAPILLOMA. Synonyms: Papillary growth, villous tumor, vegetation, verruca, wart.

Definition.—A non-malignant growth; in form pointed, round, or flat; in character hard or soft, situated upon the skin, mucous or serous membranes, and composed of epidermis and papillæ similar in structure to the papillæ normally present in the integument and certain mucous membranes.

Description.—Papillomata are of two kinds, designated respectively the corneous and the mucous. Of the former, three species are generally recognized—namely, warts (verrucæ vulgares), corns (clavi), and horns (cornua cutanea).

Warts, situated upon any region of the integument, but especially upon the hands and face, of variable size (one to twenty millimetres) and firmness, are formed of hypertrophied papillæ, having at first a rather firm covering of corneous epithelium. The original papillæ frequently vegetate, each giving rise to one or several secondary branches. The central connective-tissue framework, or papillary body, is broadest at its base, becoming narrower as it ascends the primary papillæ and approaches the extremities of the secondary branches. The epidermal layer may surround each papilla separately, or it may include several, or the entire mass, of the papillæ forming the protuberance. In the latter variety the covering is generally of not very great thickness, and the wart is soft (verruca molis vel carnea); in the former it is usually thick, giving greater firmness (verruca dura). Owing to friction and consequent detachment of the cuticle, the wart frequently loses its smooth surface and becomes roughened by minute elevations, each representing a papilla ("seed wart").

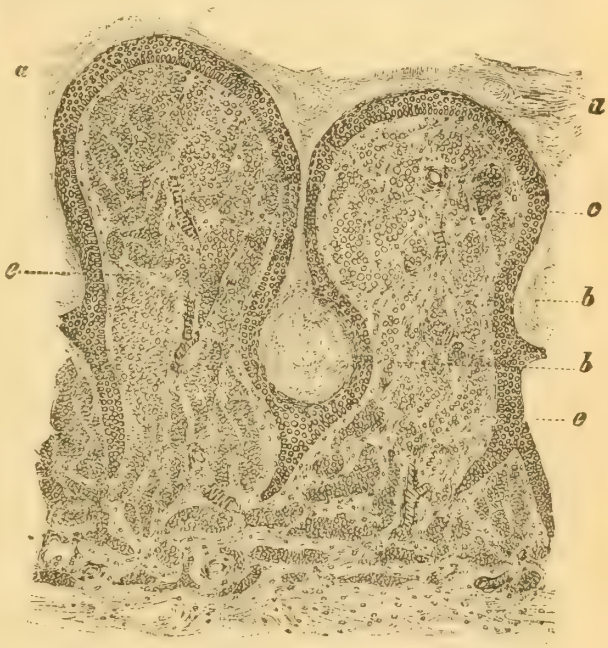

Fig. 2752.—Section through two Papillæ of a Cutaneous Wart. *a*, Corneous layer of epidermis; *b*, pearl of epithelial cells; *c*, rete mucosum; *e*, vascular connective tissue. (Ziegler.)

Corns, the result of continued pressure or friction upon the toes, occur most frequently on the little-toe, but are often located on other prominent points of the feet. When situated upon the inner surface of the toe, their epithelial covering is thinner and less firm, owing to constant maceration by the perspiration (soft corn). A corn begins as an hypertrophy of papillæ. Soon, however, the corneous layer becomes predominant, and by its increasing thickness forces down the papillæ. Later the derma undergoes atrophy, the adipose tissue is absorbed, and not infrequently a mucous bursa is formed in the subcu-

taneous cellular tissue. More or less intense inflammation, often terminating in suppuration, may also be induced by a continuation of the friction and pressure. A callosity (tylosis) bears a close resemblance to a corn, but consists almost entirely of a thickening of the corneous layer.

Horns, occurring on widely different regions of the skin, but chiefly on the face, found also in dermoid cysts, are papillomata in which the epithelial cells of the corneous layer, instead of desquamating, become firmly united in much the same manner as in the nails. The excrescences formed by these imbricated layers may acquire a considerable length and great firmness, their form depending for the most part upon extrinsic circumstances of location and pressure. Very similar to these in histological structure are the lesions of ichthyosis, a congenital affection in which papillæ of variable degrees of development are surmounted by an enormously thickened epidermal layer. Of great similarity, also, are the prominences of the skin termed neuropathic papillomata by Gerhardt, neuropathic nævi by Simon. The disease consists of papillary elevations of the skin, sometimes pigmented, supporting a rather thick layer of loose, fissured epithelium, and is peculiar to infancy. It is considered of nervous origin, because accompanied by certain neurotic symptoms, and because the eruption frequently corresponds to the distribution of cutaneous nerves, and, when unilateral, does not extend beyond the median line of the body.

Mucous papillomata differ from the corneous principally in the less development of the epithelial layer. The growths vary chiefly in two ways: First, in regard to firmness, depending upon the presence of a large or a small amount of fibrous tissue in the papillary body; and second, upon the presence of flat or columnar epithelium in the superficial layer, corresponding, as a rule, although not invariably, to the covering of the surface from which the tumor springs. Between the very hard and the very soft excrescences there are many varieties; so, between the flat-celled and the columnar, papillomata are sometimes encountered having an intermediate type of cells.

The papillæ composing a mucous papilloma may be simple (*i.e.*, single) or compound. In either form they may acquire a considerable length. The occasional large size of the compound growths is usually due to a combination with adenomata or cysts, a combination most often observed in the larynx, pharynx, gall-bladder, and alimentary tract. The most frequent seat of the mucous papilloma is mucous membrane, or more especially the transitional tissue which forms the boundaries between the mucous membranes and the integument. They are therefore most frequently encountered at the orifices of the oral cavity, of the vagina, the anus, urethra, etc. They occur also upon serous membranes, especially upon the synoviæ of the articulations; they have been observed even in the walls of the ventricles of the brain.

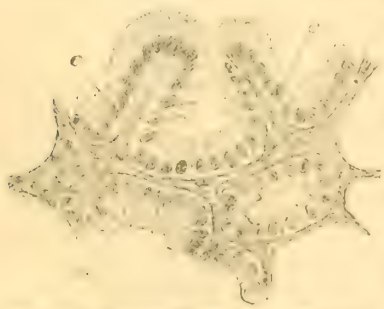

Fig. 2753. Papillary Growth into the Lumen of a Glandular Cyst of the Stomach, c, c. (Ziegler.)

Their form is round or oval, flat or bud-like, depending for the most part upon the number of secondary and tertiary branches and the direction in which they protrude, but their shape may be greatly modified by the pressure of surrounding parts.

Papillomata having columnar epithelium occur almost exclusively on mucous membranes lined by columnar epithelium, as those of the gall-bladder and ducts, the lacteal ducts, stomach, and intestines, but are sometimes encountered in the urinary bladder and on surfaces having only a single layer of flat epithelium (Fig. 2753).

Papillomata affecting the oral cavity, the uvula, the œsophagus, the vocal cords, the urinary bladder, the urethra of either sex, the vagina or uterine orifice, are, as a rule, decidedly firmer in character than those springing from other mucous membranes, owing to the larger amount of fibrous tissue, less space being occupied by blood-vessels and epithelium.

A very soft wart is frequently found upon the lip, which, owing to its tendency to ulceration, is with difficulty distinguished from epithelioma.

Papillomata situated on the mucous membrane of the gall-bladder are generally small and of little significance; sometimes, however, owing to a combination with adenomatous growth, they acquire a large size.

Papillomata of the urinary bladder are most frequently located in the trigonum, between the orifices of the ureters. They form a soft, round, very vascular tumor, sometimes of large size; or a considerable part of the mucous membrane may be covered with closely crowded villous projections.

Condyloma is a species of papilloma, having a more or less regularly branched fibrous body, supplied by a capillary vessel in each branch, and having a rather thin epithelial covering. Caused for the most part by the irritant action of morbid secretions, they are most frequent upon the genital organs, but are often encountered in other parts (see Condyloma, vol. ii., p. 260).

The soft, villous papilloma, usually simple, or having at most but one or two branches, frequently projects from otherwise healthy mucous membranes, chiefly those of the stomach and intestines, especially the colon, the urinary bladder, and the vagina, but rarely from the internal surface of the dura mater, or from the pia mater and arachnoid.

Microscopical Appearances.—The microscope resolves the papillæ of which the growth is composed into two distinct parts, a fibrous body and an epithelial covering, to which reference has already been made. The structure of the fibrous body, like that of the normal papillæ of the skin, is composed of fibrous tissue supporting blood-vessels, which terminate in capillary loops at the extremity of the papilla. The fibrous tissue is not the same in amount in all instances, and occasionally the papillæ contain no vessels. The secondary papilla has the same features as the primary, its papillary body being continuous with that of the former, its blood-vessels being offshoots from those of the parent stock. The tertiary papillæ bear the same relation to the secondary as do the latter to the primary (Fig. 2754.)

Concerning the vessels (arteries, capillaries, veins, and, probably, lymphatics) little need be said, as they usually possess the histological structure of those in normal papillæ. The capillaries, however, sometimes become dilated, uniformly or into ampullæ; they then not infrequently rupture, the blood escapes externally, or, being retained within the papillary body, becomes converted into pigment. Calcification of the vessels sometimes occurs.

The appearance of the epithelial layer of an individual papilla depends upon the character of epithelium which is present. When this is of the tessellated variety, there are usually present numerous layers dove-tailed together, the superficial cells being flattened, the whole undergoing the same mode of evolution as occurs in the Malpighian layer of the skin. Papillomata covered by columnar epithelium have but a single layer of cells over each papilla. Mucous papillomata arise as a rule from the papillæ or villi of the mucous membrane; sometimes they arise from surfaces devoid of either papillæ or villi, as from the vocal cords, the ventricles of the brain, cyst-walls, the stomach, urinary bladder, etc. The mode of origin in these localities is supposed to be similar, if not identical, with that of inflammatory granulations, of which they are doubtless in some instances a higher development. That the analogy to granulation-tissue does not hold further than the origin of the growths, however, is apparent from the fact that the latter tends toward re-

covery by organization (cicatrization), whereas a papilloma tends to persist indefinitely.

Diagnosis.—The diagnosis of papilloma is not, as a rule, attended with much difficulty, when the growth is situated in a region that is visible or of easy exploration. Where difficulty arises in these cases, it is generally in the differentiation of the mucous papilloma from other epithelial growths, especially epithelioma. Clinically, a distinction is often impossible after ulceration has occurred. The microscopical differentiation is, however, less difficult, although not always easy, being based upon the fact that in papilloma the Malpighian layer of the growth does not extend below the normal level, whereas in epithelioma it dips down into the subcutaneous cellular tissue. The presence of cell-nests favors, although it does not establish, the diagnosis of epithelioma. Another cause of error is the fact that a hypertrophy of papillæ is of frequent occurrence on the surface of many other tumors, especially when the latter are in a state of inflam-

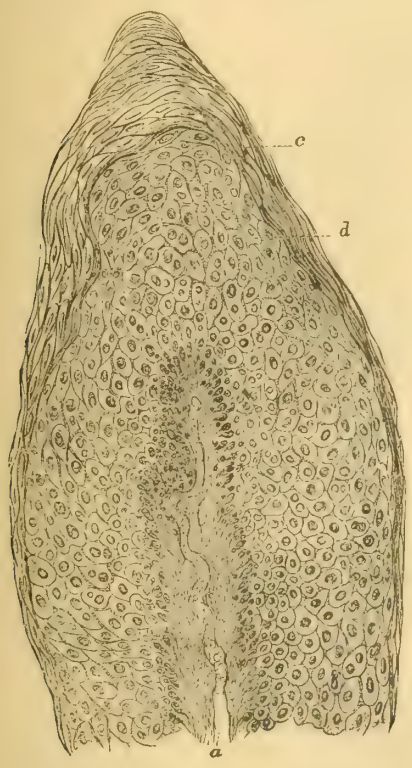

Fig. 2754.—Longitudinal Section of a Mucous Papilloma. *a*, Vascular papillary body; *d*, epithelial portion; *c*, corneous layer. (Kaposi.)

mation. To eliminate this it is necessary to examine a section through the base of the tumor. It is only when we find there a fibrous tissue devoid of gland-cells, sarcomatous elements, carcinomatous alveoli, or other neoplastic tissue that the growth can be pronounced purely a papilloma.

Prognosis.—Papilloma is a strictly benign growth. The corneous papilloma is usually of no significance. That an epitheliomatous process may be engrafted upon it, however, has been well established, and it is believed by many that a sarcomatous or a carcinomatous degeneration may occur. A wart undergoing rapid growth, especially if pigmented, is therefore to be regarded with suspicion, and its complete extirpation is, as a rule, advisable. The same is probably true of the mucous papilloma, but this is also not infrequently a direct cause of danger by hæmorrhage. Properly directed treatment is, as a rule, successful in all forms of papillomata, and in many instances the excrescences exhibit, after a time, a tendency to spontaneous resolution.

Treatment.—The treatment of papilloma must, in each instance, correspond to the character and location of the growth. Warts may be removed by the curved scissors, and a return prevented by the application of nitrate of silver, nitric acid, or glacial acetic acid; or the growth may be less rapidly removed by the application of these or similar remedies directly to its surface without preliminary excision. When the warts are numerous it is advisable to remove only a few at a time; those remaining will then sometimes disappear without further treatment.

Corns usually subside upon the removal of the pressure or friction to which they are due. The corn should be softened by bathing in hot water and pared down or extracted. The extraction may be facilitated by applying, night and morning for a few days, glacial acetic acid, or salicylic acid dissolved in alcohol (saturated solution) or in collodion (3 j. to ʒ j.) with the addition of ten grains of the extract of cannabis Indica. A ring of wadding, felt, or rubber should be placed over the corn, and properly fitting hose and shoes should be worn. The soft corn may be relieved, and often cured, by separating the toes with a small wad of cotton.

Horns may be prevented from recurring after removal (which is easily effected after they have been softened), by thorough scraping of the base with the dermal curette and by the application of arsenious acid or pyrogallic acid, or by cauterization with nitric acid, zinc chloride, or the cautery; or the entire mass of enlarged papillæ constituting the base may be excised, when practicable, by the knife or galvano-cautery.

The mucous papilloma, if situated in a region that is easily accessible, may be treated in much the same manner as the corneous wart. Thorough cleanliness, however, and the application of astringents will often suffice. Condylomata rarely resist regular cleansing and the application of an insoluble powder.

Papillomata of the air-passages, especially those of the larynx, owing to the rapidity with which they produce alarming symptoms, often call for prompt removal. Astringents and caustics should first be tried; these failing, more active measures may be resorted to. A solitary growth may be extirpated by means of the laryngeal forceps or by the galvano-cautery. Multiple growths must sometimes be removed through an external incision dividing in the median line the thyroid cartilage and the crico-thyroid membrane, preferably after a preliminary tracheotomy. This operation is sometimes necessary, also, for the removal of smaller growths in young children who cannot tolerate the introduction of instruments from above.

Papillomata of the bladder may often be relieved, for a time at least, by the cautious injection of weak solutions of nitrate of silver or acetate of lead at intervals of from three or four days to a week. Their removal has been effected by scraping with a sharp spoon through a perineal section.

Papillomata of the rectum usually yield to the application of astringents, which may be applied in concentrated form through a speculum.

These are the methods of treatment generally required. Certain cases, however, owing to the location of the growths, may call for alterations of these methods, which will, as a rule, suggest themselves and do not require present consideration. *James M. French.*

PARAISO SPRINGS. *Location and Post-office,* Paraiso Springs, Monterey County, Cal.

Access.—By Southern Pacific Railroad (Northern Division) to Solidad, one hundred and forty-three miles south of San Francisco; thence by stage to the springs, seven miles.

The springs are situated at the head of a gorge in the Coast Range, at an elevation of fourteen hundred feet above the sea. High mountains surround the place on three sides, and the views from their summits are strikingly grand and extensive. There is a large hotel, with modern improvements, and numerous cottages. The bath-house has facilities for hot soda, sulphur, and mud

baths. Good hunting and fishing are to be found in the surrounding mountains. Besides the remedial value of the waters, the air is said to be very beneficial to consumptives.

Analysis (Professor A. Ciehi).—One gallon contains:

	Grains.
Carbonate of [illegible]	1.45
Carbonate of [illegible]	1.23
Chloride of [illegible]	3.50
Chloride of [illegible]	0.35
Sulphate of [illegible]	1.32
Sulphate of [illegible]	35.50
Magnesia	Trace
Alumina and iron	1.60
Silica	2.62
Organic matter	5.25
Total	58.80

The above analysis is of the water of the Hot Soda Spring (120° F.). In addition there is a Hot Sulphur Spring (114° F.), containing a large percentage of sulphate of soda, sulphate of lime, and carbonate of magnesia.

Therapeutic Properties.—These are valuable thermal waters, diuretic and aperient. They differ from the Carlsbad only in degree. They are useful in chronic, congestive, and catarrhal disorders of the digestive apparatus, and as baths in rheumatism and gout.

George B. Fowler.

PARALDEHYDE: Parethylaldehyde: $3\,(C_2H_4O) = C_6H_{12}O_3$. Paraldehyde is a polymeride of common ethylic aldehyde, producible by the action of a considerable number of substances upon such aldehyde. Paraldehyde is, at ordinary temperatures, a liquid, colorless, of a burning taste and powerful and penetrating ethereal odor. It dissolves in 8.33 volumes of water. At temperatures below 50° F. paraldehyde solidifies to an ice-like, crystalline mass, or may crystallize in distinct prisms. Paraldehyde is peculiar among ethereal bodies for possession of the property of determining *sleep*, with a minimum of by-effects. The sleep produced by the medicine seems a quite perfect imitation of natural slumber, since the subject under the influence of the hypnotic is as easily awakened as from ordinary sleep. No worse derangements occur from the medicine than a little dryness of the throat and thirst, and a trifling reduction of pulse-rate and arterial tension. In particular, appetite and digestion are little affected. The most disagreeable circumstance attending the use of paraldehyde is a persistence of the taste of the drug upon the palate, and of the odor in the breath, often for a number of hours after the taking. The sleep produced by a perfectly legitimate dose of paraldehyde may begin within fifteen minutes after the swallowing, and last five, six, or seven hours. The medicine is used exclusively for the procurement of sleep, and is applicable, without special contra-indication, for any case where that therapeusis is proper. A quantity of from two to four grammes (from thirty to sixty minims) is the average dose, and the same is best given dissolved in thirty grammes (one fluid-ounce) of an aromatic water, sweetened. *Edward Curtis.*

PARALYSIS AGITANS. Synonyms: Shaking palsy, Parkinson's disease.

Etiology.—Paralysis agitans is one of the diseases of advancing years, and the large majority of cases develop after the age of forty to forty-five years. It is a mistaken idea, however, to regard it as an indication of senility. In a few exceptional instances the disease has begun at a much earlier period, and cases have been reported at the age of twenty, seventeen, twelve, and even three years. It is very often difficult to determine the exact period at which it begins, because the inception is usually very gradual and is often unnoticed by the patient.

Unlike other neuroses, heredity plays a very slight part in this affection. Few cases have been reported in which other members of the patient's family suffered from this or some other form of nervous disease.

Paralysis agitans is a rare disease. Among 4,600 patients under my observation, during the last eleven years, at the Clinic for Nervous Diseases in the Bellevue Out-door Department, there were 30 examples of paralysis agitans, 19 of which occurred in males, 11 in females.

It has been said that the Anglo-Saxon race is especially predisposed to the disease. At all events there can be no doubt that reports of cases are comparatively rare in the otherwise very prolific German literature on nervous affections. We may also state, with regard to New York, that the disease is frequently mistaken here for senile tremor or multiple cerebro-spinal sclerosis.

Prominent among the exciting causes stands emotional excitement, usually of a depressing nature, such as fright and anger. Several cases of this kind were observed among the inhabitants of Metz and Strasburg during the sieges experienced in the Franco-Prussian war. Lorain (*Arch. de Méd.*, vol. i., 1875, p. 214) reports the following striking example: A girl, aged seventeen, was frightened by the bursting of a shell in the cellar in which she had taken refuge during the siege of Paris. This was followed immediately by tremor of the right arm, which soon extended to the rest of the body. At the end of five years she was still suffering from paralysis agitans.

Long-continued worry and grief appear to act in the same way as sudden emotions.

Living in damp rooms, or protracted exposure to wet and cold, are also said to give rise to the disease, and in our experience this has seemed to be the most efficient of all the etiological factors. Some patients inform us that the tremor began immediately or shortly after catching cold, from a single exposure to wet or cold, but it is doubtful whether there is any real connection between the two events.

Fig. 2755.—(After Struempell.)

A number of cases have been reported in which the disease had a local origin in an injury to the arm or leg (sometimes, perhaps, as the result of a peripheral neuritis). In such cases the tremor begins usually in the injured part, but then spreads to the rest of the body and pursues the ordinary course of paralysis agitans.

Ball claims that paralysis agitans and insanity are associated more frequently than is commonly believed. The insanity, according to this writer, is always of a depressive character, generally melancholia with suicidal impulses and numerous hallucinations. In some cases a condition of dementia and of "demi-stupor" predominates.

Clinical History.—When the disease begins slowly, as usually happens, it is sometimes preceded by prodromi, which consist of wandering pains in different parts of the body, occasional formication, or a feeling of weakness in the parts that are attacked at a later period by the tremor. In some instances the tremor does not remain constant after its first appearance, but subsides at times until again provoked by some exciting cause. In rare cases the disease begins suddenly, as we have seen in the section on etiology, and may spread quite rapidly to the entire body.

In the majority of cases tremor first appears in an arm or leg (usually the former), and then extends to the other limb on the same side. After a longer or shorter time (sometimes several years) it spreads to the other side of the body, generally attacking the latter in the same order. The head and trunk may also become involved. Charcot

claimed that the apparent tremor of the head was always the result of the transmission of the movements of the trunk and limbs. This has been disproven by numerous cases, and several instances have fallen under our own observation. In rare cases the tremor first attacks the arm of one side and the leg of the opposite side, or it assumes a paraplegic form, involving both lower limbs. But sooner or later it extends to the rest of the body.

Coincidently with the tremor (in some cases even preceding it) the muscles of the body acquire a certain degree of rigidity, and the body assumes a peculiar, almost pathognomonic, position, as shown in Fig. 2755.

The motor power of the limbs remains comparatively unchanged for a long time, even for many years, but in the last stages general paralysis sets in. Sensation is unaffected throughout the entire course of the disease. The reflexes are unchanged. Unless life is terminated by some intercurrent disease, the patient finally lapses into a condition of mental hebetude, becomes bed-ridden, loses power over his limbs, the functions of the bladder become impaired, bed-sores develop, and finally death ensues.

We will now enter into a more detailed examination of the various symptoms.

The tremor, which is one of the most striking features of the disease, and the one from which, in fact, it derives its name, consists of very quick, uniform, and limited excursions of the affected parts during repose. In the first stages the patient is able to control the tremor for a time by an effort of the will, or by executing a voluntary movement of the parts. But as the disease advances this ability is diminished, and, finally, while the patient may, for a very brief interval, moderate the severity of the tremor, a voluntary effort is soon followed by increased violence of the movements. The tremor subsides during sleep, but the patients are very restless at night and do not remain long in one position. Its cessation on voluntary effort was regarded by Charcot as a pathognomonic differential sign from the tremor of multiple sclerosis. But Westphal has reported a case in which the tremor of sclerosis presented the same characteristics as that of paralysis agitans; and a similar case, in which an autopsy was obtained, has come under my own observation. Magnan has also reported a case of paralysis agitans, in which the movements did not occur unless the patient performed some voluntary act which required a certain degree of attention on his part. As a rule, the fingers and forearm are the parts most affected; next follow the foot and leg. In the large majority of cases the head also presents rhythmical movements, but these are generally conveyed from the trunk and limbs. In not a few cases, however, certain of the facial muscles, particularly of the lips and chin, present tremulous movements similar to those of other parts. In still rarer cases the tongue, when protruded, also presents oscillatory movements, but these are never so pronounced as in other muscles.

The appearance of the body, when the disease is fully developed, is highly characteristic and, indeed, almost pathognomonic.

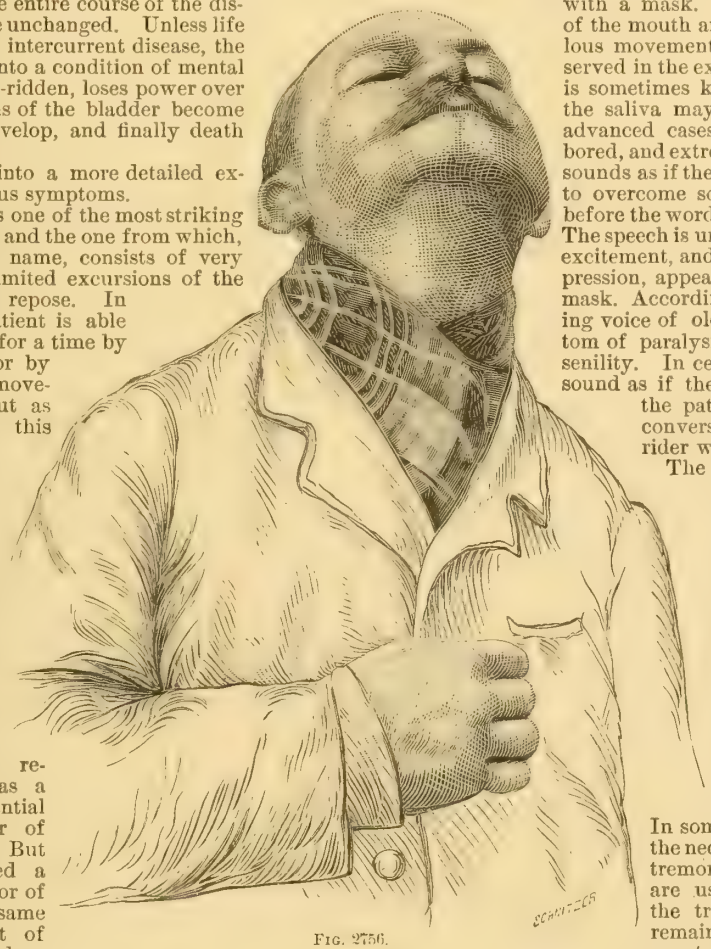

Fig. 2756.

The face has a peculiarly stolid, rigid appearance. The eyes have a dull, lack-lustre look, and their movements are slow, as if the muscles were rigid like those of the face and rest of the body. Two cases have been reported in which so-called ocular lateropulsion was observed. The patients, while reading, experienced a certain amount of difficulty in directing the gaze from the end of one line to the beginning of the next line. This is most marked if the reading-matter is arranged in columns. When they have arrived at the end of a line, the eyes involuntarily seek the corresponding line in the next column, because the ocular muscles cannot be moved with the normal rapidity.

The facial muscles have lost their emotional play almost entirely, and the face therefore looks as if covered with a mask. At times the muscles of the mouth and chin present tremulous movements similar to those observed in the extremities. The mouth is sometimes kept slightly open, and the saliva may dribble constantly in advanced cases. Speech is slow, labored, and extremely monotonous. It sounds as if the muscles of speech had to overcome some unusual resistance before the words could be enunciated. The speech is unchanged by emotional excitement, and, if we may use the expression, appears to be covered by a mask. According to Buzzard, the piping voice of old age is really a symptom of paralysis agitans, and not of senility. In certain cases the words sound as if they were jolted out of the patient's mouth, like the conversation of an unskilful rider while on horseback.

The head is held forward, and the chin may even be closely approximated to the sternum. The muscles of the neck are usually rigid and offer considerable resistance to passive motion. Three cases, I believe, have been reported in which the head was drawn backward instead of forward. A fourth one has come under my observation, and is illustrated in Fig. 2756. In some cases the muscles of the neck present independent tremor, but their movements are usually conveyed from the trunk. The head will remain quiet in the latter event, if the movements of the body are forcibly restrained. The trunk is generally in a condition of antero-flexion, as shown in Fig. 2755. The arms are usually drawn slightly forward, and the elbows are slightly separated from the side of the chest. The forearms are strongly flexed, partly pronated, and ordinarily lie across the abdomen. These parts are in a state of constant tremor, though this is not so vigorous as in the hands. The fingers are usually flexed, the thumb adducted, and also very slightly flexed. The thumb and index-finger are continually moving to and from one another, as in the act of writing, or making pills; the other fingers are in a condition of constant fine tremor. In other cases the position of the fingers resembles that of arthritis deformans, but the joints are not swollen as in the latter disease.

The lower limbs are moderately flexed at the thighs and knees, and the latter are drawn inward. The feet are in the position of equino-varus. The toes are extended

at the first phalangeal and flexed at the other phalangeal joints.

The tremor of the muscles is generally increased when the patient is conscious that he is under observation, or when he is excited from any cause. At certain times it is more vigorous than at others. In the first stages it may be abolished by voluntary effort, but as the process advances this becomes impossible, except for a very short period. In Magnan's patient the tremor occurred only on voluntary effort.

The patient's gait is also very characteristic. Upon attempting to rise from a chair a certain amount of difficulty is experienced, as if he were compelled to overcome some resistance. He stands still for a moment, as if to steady himself, and then makes short, shuffling steps. The gait gradually increases in rapidity, and soon passes into a sort of slow dog-trot. In many cases the patient loses his balance and falls, unless supported. Others measure with the eye the distance between the starting-point and their objective point, and learn to regulate their muscular effort in such a way as to barely reach their destination in safety. This so-called festinating gait has been attributed by most writers to the forward displacement of the centre of gravity of the body, so that the body is, as it were, hurried along in order to catch the centre of gravity. This explanation is insufficient, as is shown by the phenomena of propulsion and retropulsion. In some cases, if, while the patient is standing still, slight traction in a forward direction is exercised upon his clothes, he will be irresistibly impelled to move forward in the peculiar manner described above (propulsion). In rare cases, if the traction is exercised backward, the patient will move in this direction in a similar manner (retropulsion). In retropulsion, indeed, he is moving in a direction opposite to that of the action of the centre of gravity. Retropulsion and propulsion have also been regarded as forced movements, like those produced by irritation of the cerebral peduncles.

The muscular power of the patient is not much diminished until he becomes bed-ridden, but he is very easily tired by muscular exertion. Furthermore, an unusually long time elapses before the patient is able to execute any voluntary movement, and when this has been begun it cannot be discontinued as abruptly as in health. This may be readily detected by directing the patient to squeeze one hand firmly and rapidly, and comparing this action with that of a healthy individual. Although the difference is often quite decided, the dynamometer may fail to reveal any real loss of power.

Many patients suffer constantly from a feeling of heat in the skin, or from sudden flashes of heat. In addition, they complain of an indefinable internal restlessness which impels them to change position very frequently. This is often very distressing at night, since many of the patients are unable to turn voluntarily from side to side on account of the rigidity of the muscles of the trunk.

The cutaneous and tendon reflexes and sensation are unaffected; the sufferer may complain occasionally of pains in the limbs, but chiefly in the back.

As the disease advances the muscular power of the patient is gradually impaired, and finally he is compelled to remain in bed. Then bed-sores may develop, the sphincters of the bladder and rectum become paralyzed, and the patient finally dies of exhaustion. In these cases the mental powers are also apt to undergo very marked deterioration.

Probably in the majority of cases, however, death is the result of intercurrent diseases, among which pneumonia seems to play an important part.

In rare cases paralysis agitans seems to run its course without tremor. Such patients present all the other evidences of the disease—muscular rigidity, characteristic position of the body, festinating gait, speech-disturbances, the sensation of superficial heat, etc.—but the tremor is entirely absent, or is observed only at times to a mild degree.

Pathological Anatomy.—In many of the older cases, patches of sclerosis have been found in different parts of the brain and spinal cord. But these cases should be disregarded, inasmuch as they were probably instances of multiple sclerosis, and not of true paralysis agitans.

Such competent observers as Charcot, Ordenstein, and Westphal have reported cases in which the most careful post-mortem examinations failed to discover the existence of any lesion in the nervous system. Other writers have detected lesions in the brain or spinal cord, or in both organs.

The following changes have been observed in the spinal cord: Congestion and softening of the medulla oblongata; chronic circumscribed meningitis over the calamus scriptorius; obliteration of the central canal of the cord from proliferation of the epithelium, with pigmentation of the nerve-cells, especially in Clarke's columns; congestion of the gray commissure and dilatation of the peri-vascular spaces, with a coagulated exudation in the central canal; peri-ependymitis; sclerosis of the columns of Goll; disseminated myelitis in the antero-lateral columns.

The cerebral changes noted are as follows: Softening of the pons and a portion of the medulla oblongata; sarcoma of the left optic thalamus, with softening of the pons; fibroid tumor of the pons; sclerosis of Ammon's horn; atrophy of the anterior convolutions, cerebral peduncles, and pyramid tracts; atrophy of the corpus striatum; sclerosis of the cerebral peduncles and pons Varolii; atheroma of the vessels of the base of the brain, granular and pigmentary degeneration of the nerve-cells at the level of the decussation of the pyramids, olivary body, nucleus of the ninth nerve, etc.

In view of the diversity and inconstancy of these lesions, and of the fact that post-mortem examination sometimes furnishes purely negative results, we are forced to the conclusion that the nature of the disease is still unknown, and that we are even unable to determine whether it is cerebral or spinal in its origin. Indeed, Strümpell even goes so far as to suggest that the malady is primarily myopathic. But while we think that the clinical history of the disease strongly favors its neurotic origin, we must nevertheless confess, that not only is its pathological anatomy obscure, but also that the theories hitherto advanced in explanation of the individual symptoms have not been substantiated.

Diagnosis.—When the disease is fully developed the diagnosis is extremely easy. But in its early stages it may be mistaken for multiple cerebro-spinal sclerosis, senile tremor, or toxic tremor, especially after mercurial poisoning.

Multiple sclerosis is distinguished by the following symptoms: The tremor is coarser and not so rhythmical as that of paralysis agitans, and, with the exception of very rare cases, it occurs only during the performance of voluntary movements. The characteristic position of the body and the peculiar appearance of the face are wanting, while nystagmus, diplopia, and various other cerebral symptoms of serious import are present.

Senile tremor may be as uniform and fine as that of paralysis agitans, but it generally begins in the muscles of the head and neck, and is uninfluenced by repose or motion. The head may be bent forward, but rather as the result of bowing of the back. The patient does not suffer from the peculiar restlessness of paralysis agitans, and the muscular rigidity incident to the latter is wanting. There are also other evidences of senility.

In mercurial tremor, examination will always show that the affection has been preceded by the buccal symptoms of mercurial poisoning. The disease is also attended by greater impairment of muscular power and general prostration. The tremor is much more marked during action than during repose. In severe cases it is said to be attended, at times, with profound deterioration of the mental faculties. This affection appears to be extremely rare in New York, and the very few cases which have come under my observation have occurred in looking-glass makers.

Post-hemiplegic chorea sometimes appears as a fine muscular tremor, and, at first sight, may be mistaken for paralysis agitans, especially in view of the fact that

there is considerable restoration of muscular power in the paralyzed side before the tremor begins. In addition, there is always rigidity of the affected parts. But the clinical history shows that the disease began with an apoplectic attack, and, in addition, the tendon reflexes are always exaggerated. Finally, the subjective symptoms of paralysis agitans are wanting.

Prognosis.—No authentic case of recovery from this disease has been heretofore reported. Indeed, recovery might be looked upon as convincing proof of an error in diagnosis.

During the first stages of the disease temporary remissions sometimes occur, but after a time it shows slow but uninterrupted progress.

The patients usually die of an intercurrent disease, and in many cases life does not appear to be shortened by the malady. Cases have been reported in which it continued more than thirty years.

Treatment.—The most that can be hoped for from treatment is to produce a certain degree of palliation of the symptoms. In our own hands slight benefit has been derived, in a few cases, from the use of galvanism, nitrate of silver, hyoscyamine, and prolonged rest in bed. Electricity has been employed by me in the form of the constant current of moderate strength, one electrode on the upper cervical spine, the other on the lower dorsal region; sittings three times a week, five to ten minutes' duration. This plan of treatment must be continued for a long time in order to produce any good results whatever. Nitrate of silver may be given in pill-form for a year or more consecutively, but it is well to intermit its administration from time to time. The dose may vary from gr. $\frac{1}{6}$ to $\frac{1}{3}$ t.i.d.

Hyoscyamine sometimes produces very rapid and brilliant temporary results in diminishing the tremor. Even when the tremor is very violent and wide-spread, it may subside almost completely in a few days. The initial dose should not exceed gr. $\frac{1}{100}$, but this may be gradually increased until the physiological effects are produced. But unfortunately the good effects of this remedy cease as soon as it is discontinued, and it does not seem to us to be entirely safe to give it continuously in sufficient doses for any length of time.

Absolute rest in bed may also exert a favorable influence, but it is very difficult, on account of the great restlessness of the patient, to secure his consent to prolonged treatment in this way. *Leopold Putzel.*

PARALYSIS, DIPHTHERITIC. The frequency of post-diphtheritic paralysis has been variously estimated at from three per cent. to sixty per cent. of the cases of the primary disease, figures which show conclusively that it is impossible to arrive at the truth with reference to this matter. The reason of this is that diphtheritic paralysis is a disease of convalescence. Patients are lost sight of, in many cases, before the sequela has had time to manifest itself. It is certain that the paralyses of diphtheritic origin are more numerous than those of all the other acute diseases combined, and that the physician who has successfully treated a case of diphtheria will do well to exercise a certain degree of reserve with regard to a prognosis of speedy convalescence or even of ultimate recovery.

Symptoms.—In the great majority of cases the muscles first affected are those of the soft palate. This is indicated by the regurgitation of fluids through the nose and by a nasal tone of voice, such words as "*rub*, *head*, and *egg* becoming *rum*, *hent*, and *enk*." The time of these manifestations is usually in the second or third week after the complete subsidence of the angina, although, on the one hand, they have been observed during its course, and, on the other, have been postponed until the sixth week of convalescence. On inspection the velum and uvula are seen to hang in a flaccid condition, and to move backward and forward during respiration. Sometimes the paralysis of the soft palate is unilateral, and when bilateral it is more pronounced on one side. With it may be associated paralysis of the constrictors of the pharynx and of the depressor of the epiglottis, rendering deglutition an act dangerous to life. As a rule, it is not until the paralysis has become general that the muscles of the larynx are involved. When these are all paralyzed, respiration is not interfered with except on exertion; the vocal cords are motionless and assume what is known as the "middle position," falsely called the "cadaveric position." When the posterior crico-arytenoid muscles are alone affected, the interference with respiration may be so great as to render necessary a resort to intubation of the larynx or to tracheotomy. The dangers attendant upon a loss of power of the muscles of the larynx are greatly aggravated by a simultaneous anæsthesia of its mucous membrane from paralysis of the superior laryngeal nerve. Under these circumstances particles of food are certain to enter the trachea, and, if small, will reach the bronchi and give rise to atelectasis and traumatic pneumonia, while larger masses may occlude the trachea and cause sudden death. Two cases of death from the latter cause are recorded by Espanet ("Du Prognostic des Paralysies Diphthéritiques," Thèse de Paris, 1883).

The disorders of innervation may remain limited to the soft palate and pharynx, or they may become general. In the latter event the ciliary muscle is generally the next to lose its motility. In reading and in distinguishing near objects a difficulty is experienced, which may be demonstrated to be due to paralysis of the ciliary muscle by the fact that it is overcome by convex glasses. Unlike the paralysis of accommodation caused by atropia and other mydriatics, it is not accompanied with mydriasis. Misleading terms have been applied to this disorder. Thus, in several of Maingault's admirable reports, the "blindness" is said to have been complete—"la cécité est complète." The "blindness" consists in an inability to focus divergent rays of light, parallel rays being focussed and perceived without difficulty. The degree of this ciliary paralysis is variable. According to Remak, who observed 100 cases of post-diphtheritic paralysis of the intra-ocular muscles, in some it "was so slight as only to bring to the surface a certain amount of latent hypermetropia, and in some it required +4.00 D. to enable the patient to read small test-letters at ten or twelve inches. He divides his cases into three classes: Severe, requiring from +3.00 D. to +4.00 D. to read with, as above; medium, requiring +1.50 D. to +3.00 D.; and light, needing less than +1.50 D. Dividing his cases as above, he classifies 24 cases as severe, 16 cases as light, and the remaining 60 cases as of medium severity. He states that severe paralysis sometimes follows a very mild attack of diphtheria, and that the converse is also true. In these 100 cases there was not a single case of optic neuritis." (From report on "Progress in Ophthalmology," by Drs. O. F. Wadsworth and Myles Standish, in *Boston Medical and Surgical Journal*, December 2, 1886.) In addition to the paralysis of accommodation there may be diplopia, strabismus, and ptosis from paralysis of the oculo-motor nerve.

The next muscles to lose their power are those of the lower extremity, and here, as elsewhere, disturbances of sensation usually precede those of motion. Numbness, tingling, formication, sometimes pain and hyperæsthesia, are first complained of, and soon after muscular weakness or ataxia is plainly evident. The loss of motor power may be incomplete amounting to paresis rather than paralysis, or it may advance to complete paraplegia. Loss of tactile sensibility may persist after the power of motion has been restored, so that the patient, in walking, makes use of his eyes to assure himself that his feet are on the ground. He feels as if walking in the air. In such cases ataxic symptoms manifest themselves in the course of recovery from the paralysis; and a case seen for the first time in this stage will almost certainly be mistaken for one of tabes dorsalis, a diagnosis that is rendered apparently certain by the absence of the knee-jerk. Sometimes sensation is abolished without loss of motion, and here ataxia is present from the beginning. Thus, in one of Duchenne's cases there was complete anæsthesia and analgesia in the extremities, while the muscular power, as tested by the dynamometer, was found to be

unimpaired. In this case the analgesia disappeared before the tactile sense was restored.

The knee phenomena after diphtheria have been carefully studied by Professor Martin Bernhardt (*Virchow's Archiv*, Bd. 99), who found the patellar tendon reflex absent in a great number of cases, most of which were of a severe type. It usually disappears a few weeks after recovery from the angina, although its presence within five to eight weeks thereafter affords no guarantee that it will not disappear at a still later period. The knee-jerk may remain absent for some time after all signs of paresis or ataxia have disappeared. There is no relation between the skin-reflex and the knee-jerk, the former being often present when the latter is extinct. Observations upon the knee-jerk are only of value in cases in which the function of the quadriceps extensor femoris has been demonstrated to be intact.

The muscles of the upper extremities are more rarely affected than those of the lower, but if the paralysis continues to advance, they are the next to lose their power. Disorders of sensation, such as tingling and formication, precede those of motion, and more or less complete anæsthesia and analgesia are associated with the motor paralysis. There may be marked ataxia, it being impossible to perform an almost automatic movement, such as fastening a pin; or the loss of tactile sense may be so great that an object cannot be held in the hand unless the gaze is kept fastened upon it. Paralysis of the muscles of the neck and trunk, rendering it impossible to hold the head erect without support, or to turn in bed without assistance, and of the sphincters of the bladder and rectum, causing incontinence of urine and fæces, are among the rarer and later disturbances of motion. In some rare instances constipation has been so obstinate that it must have been caused by atony of the muscular coat of the intestine, or by a paralysis of the rectum, or by both combined. In one of Maingault's cases (Obs. 31), the patient passed twenty-three days without a fecal evacuation. When the paralysis is general, anaphrodisia invariably exists, and may continue for months after the disappearance of every other symptom of disordered innervation. Paralysis of the muscles supplied by the portio dura of the seventh cranial nerve is rarely observed. A case is recorded by Pératé in his thesis. Among the graver forms of paralysis, in addition to that of the larynx (previously mentioned), are those of the diaphragm and of the heart. The former, although serious, is not necessarily fatal, provided the patient avoids all unnecessary movement, or, in general terms, that no unusual demand is made upon the respiratory function. Should pulmonary congestion, bronchitis, or broncho-pneumonia supervene, death is almost inevitable. Dr. D. P. Bissell ("Trans. New York State Med. Soc.," 1862) has reported five cases of sudden death in diphtheritic paralysis, apparently from paralysis of the heart. "The action of the heart would be suddenly arrested. Sometimes when the little patient was sitting up talking with those around him, or amusing himself with his toys, life became extinct, without disturbing a muscle or occasioning a groan." The pulse was, in all the cases, "soft, feeble, and easily computed, in most of them it was slow or rather infrequent, sometimes not more than thirty beats in a minute, while in two or three instances it was extremely quick and feeble, so that it could scarcely be counted." Greenhow has seen three cases of death from failure of the heart's action. "In one of them it was sudden, apparently from syncope; in the others more gradual, the pulse becoming slower and slower until, in one instance, it fell below thirty beats in the minute." Espanet also records several cases of sudden death from heart-failure.

The symptoms of this fatal accident are præcordial distress, with excessive dyspnœa, and slowness, feebleness, and irregularity of the pulse. The expression is altered, and the face is bathed in perspiration. The sounds of the heart are confused, badly accented, and its pulsations very irregular.

The above mentioned are the principal forms of post-diphtheritic paralysis, but no muscle of the body can be considered exempt from liability to this form of palsy. Changes in the electrical reactions of the paralyzed muscles may or may not be present. The reaction of degeneration has been most frequently observed in the paralyzed muscles of the palate, but may be given by the muscles of the extremities.

Concurrently with the disorders of innervation the general health may be markedly impaired. A patient apparently convalescent may become pale, thin, and irascible, with loss of appetite, and a slow, feeble pulse that may descend to fifty in the adult; and with these prodromal symptoms of paralysis there is a complete absence of fever.

Etiology.—In discussing the etiology of a sequel, the first question is whether there is anything in the nature of the primary attack to determine the onset of the secondary. Bretonneau was of the opinion that diphtheritic paralysis was of more frequent occurrence when the primary affection had invaded the nasal passages, on the ground that diphtheritic coryza indicates a profound intoxication. Morell Mackenzie, on the other hand, holds that "the severity of the paralytic symptoms bears no proportion whatever to the severity of the antecedent disease." This is also the view of Jacobi, who says that it is erroneous to suppose "that the severity of the paralysis depends on the severity of the original sickness." There have been cases of diphtheria so slight that the subsequent paralysis was their first decided symptom. Statistics to determine the influence of age and sex in the causation of post-diphtheritic paralysis have not, so far as I know, been collected upon a large scale. If age exerted no influence, the greatest number of cases would occur during that time of life in which diphtheria is most prevalent—namely, between two and six years; but this is not the case. In a table of sixty-eight cases of diphtheritic paralysis, drawn up by Landouzy, the greatest number occurred between ten and thirty years of age, and between thirty and sixty-three—that is, at a time of life when diphtheria is comparatively rare—paralysis was not uncommonly met with. The influence of sex is slight, if, in fact, there is any. Of 38 cases tabulated by Roger, 21 were girls and 17 were boys. The figures are too small to warrant conclusions. It was at one time supposed that albuminuria during diphtheria might be a causative factor of the subsequent paralysis, but this view was abandoned after the observation of a number of cases without albuminuria which were followed by paralysis. Predisposition cannot be excluded from a consideration of the causes of diphtheritic paralysis. A neuropathic constitution may determine the occurrence of paralysis, just as the primary angina determines the site of its first manifestation. With reference to this last point, there can be no question that the site of the diphtheritic exudation is of decided influence in determining that of the first appearance of the paralysis. In the great majority of cases diphtheria first attacks the throat, and the velum and neighboring parts are the first to be paralyzed; but when the diphtheria is cutaneous, the rule, with reference to the subsequent paralysis, still holds good. In a remarkable case reported by Dr. A. R. Paterson, of Aberdeen, Scotland, a man inoculated a wound on his right index finger by passing it into the throat of his child who was dying of diphtheria. A sloughing wound resulted, which, a week later, had entirely healed. About a month after he was attacked with paralysis, which, *beginning in the right arm*, gradually attacked all four extremities, reducing them to a condition of complete akinesia. The throat was never affected, either with angina or paralysis. Pitres and Vaillard (*Archives de Neurologie*, xi., 337) relate a case of diphtheritic paralysis, the subject being tuberculous and the diphtheria cutaneous, appearing first on a vesicated surface in the left subclavicular region. The first symptoms of disordered innervation were vague, contusive pains, most marked in the left shoulder and aggravated by movement and by pressure. A case is also referred to by Starr ("Middleton-Goldsmith Lectures") in which "paralysis of the abdominal muscles was associated with diphtheritic inflammation of the navel in a new-born child."

Anatomical Characters.—While it is true, as Jacobi says, that "diphtheritic paralysis does not, in every case, depend on one and the same cause," there can be no doubt that the lesions, in the majority of cases, are those of peripheral neuritis. Central changes have been found by Buhl, Déjerine, Vulpian, Abercrombie, Kidd, and others; but in the reports of their cases there is no record of such a careful examination of the peripheral nerves as is often necessary to detect the lesions of diphtheritic neuritis. Buhl found numerous small extravasations of blood in the brain, with points of softening at their periphery. The anterior and posterior roots of the nerves, including the ganglia of the latter, were swollen to nearly double their normal size, and were colored dark red by extravasated blood. The cord itself was not affected, and the nerve-trunks were not examined. In a case reported by Dr. Percy Kidd ("Medico-Chirurgical Trans.," 1883) there were distinct evidences of polio-myelitis anterior, the patient, a boy aged seven, having died of paralysis of the intercostal muscles. At the time of Dr. Kidd's paper there had been reported fifteen cases of diphtheritic paralysis in which changes in the motor cells of the cord were found—viz., five by Déjerine, who was the first to bring forward "definite facts in favor of diphtheritic paralysis being due to a degeneration of the motor nerve-cells of the spinal cord;" two by Vulpian; seven by Abercrombie; and one by Kidd. Against these are to be placed four cases—those of Hermann Weber, Oertel, Pierret, and Vulpian—in which microscopic examinations showed no evidence of anterior polio-myelitis. Dr. Kidd acknowledges his inability to account for these negative results, but nevertheless clings to the belief that "diphtheritic muscular paralysis will be shown to depend upon a polio-myelitis anterior."

Déjerine also declares this lesion to be constant ("cette lésion est constante; nous l'avons toujours rencontrée dans nos examens," *Archives de Phys. Norm. et Path.*, 1878). If the changes, such as have been found in the anterior cornua in certain fatal cases, were the usual cause of diphtheritic paralysis, that affection would be rarely recovered from. A certain amount of paralysis and atrophy would be permanent, and the electrical reactions of the paralyzed muscles would invariably be those of degeneration. Finally, such an affection of the anterior cornua could not possibly account for the disturbances of sensation—the anæsthesia, formication, numbness, pain, and tenderness of muscles and nerve-trunks so commonly observed. In the great majority of cases the lesion is peripheral and the recovery is complete. Charcot and Vulpian were the first to examine the nerves, those of the velum, in a case of diphtheritic guttural paralysis. They found many nerve-tubes without medullary matter; others in which the white substance was broken up into fine granulations; also nerve-bundles composed of healthy and diseased tubes, and suggested that the latter might be motor fibres, the former sensory ("Comptes Rendus de la Soc. de Biologie," vol. iv., 1862). In 1869 Liouville examined the phrenic nerves of a subject who died suddenly of asphyxia in the course of a post-diphtheritic paralysis, and found alterations similar to those described by Charcot and Vulpian. Dr. Ulysse Bailly, in his thesis entitled "Des Paralysies consécutives à quelques maladies aiguës" (Paris, 1872), remarks that, on the rare occasions in which the nerves in diphtheritic paralysis were examined, they were profoundly altered. Jacobi believes in the peripheral origin of the paralysis, although he is not clear as to its precise nature. He says that "in most cases diphtheritic paralysis consists of a trophic affection of the motory system, almost always peripherically in nerves and muscles, seldom, if ever, in the centre." Perhaps the most recent contribution to this subject, certainly one of the most interesting, is that of Pitres and Vaillard, in the *Archives de Neurologie*, vol. xi., p. 337. These observers noted the ordinary changes of diphtheritic neuritis which are identical with those of the so-called Wallerian degeneration, and, in addition, a neuritis existing *in segments* of from three to eight millimetres in length or sometimes affecting but a portion of one interannular segment. In the latter case the inflammation was always in the immediate neighborhood of one of the nodes of Ranvier.

The nerve above and below the affected segment was absolutely normal. The process is the same in its beginning as that described by Gombault in the case of guinea-pigs poisoned with lead. The myeline breaks up into fine black or gray granulations, generally united in round masses containing in their centre a large nucleus and resembling somewhat the corpuscles of Gluge. The granular masses gradually disappear, and, at the same time, the fibre becomes narrower in certain points, which gradually extend to the whole of the diseased portion until the tube is reduced to the sheath of Schwann surrounding a variable number of nuclei. The axis-cylinder has now entirely disappeared. This segmentary neuritis may also take place in a different manner. In the course of a nerve-fibre one or more segments may be seen presenting the same alterations that occur in the periphery of a nerve after section of its trunk. The myeline breaks up into large blocks, instead of fine granulations as in the preceding case, separated by a granular protoplasm and by nuclei. The multiplication of the latter is less active than in the former variety, but the destruction of the axis-cylinder is quite as complete. Above and below the diseased segments, in both varieties, the nerve-tube is quite normal, and this fact, which appears to be contrary to the recognized laws of the Wallerian degeneration, would seem to demonstrate a certain physiological and pathological individuality of the interannular segment. In all the cases examined by Pitres and Vaillard, besides the segmentary neuritis, there were fibres which exhibited in their entire length the changes of the Wallerian degeneration. These writers insist upon the importance of great care in searching for the alterations which they describe. A nerve profoundly altered may be considered healthy unless a considerable portion of its course is examined. The fibres also should be dissected, because a bundle containing a number of diseased tubules may present a perfectly healthy appearance.

Diagnosis.—When the paralysis is the early sequel of a well-marked diphtheritic angina the diagnosis is self-evident, but if the primary disease has escaped notice on account of the insignificance of its local and general manifestations, or the unusual situation of the exudate, the greatest care may be necessary in order to avoid mistakes. Under the latter circumstances the ataxia of the extremities, so marked in many cases, with loss of knee-jerk, may lead to the diagnosis of tabes dorsalis. The general paresis, the feeble, stammering speech, and the visual disturbances may simulate progressive general paralysis. The strabismus, combined with general weakness, apathy, and slow pulse, may closely resemble the effects of cerebral tumor or cerebral meningitis. In children the difficulty in speech, the nasal voice, and the uncertain walk give the appearance of idiocy. Maingault reports the case of a child, aged eight, who was brought to Professor Gosselin by its father in order that it might be admitted to an asylum for idiots, the diagnosis of idiocy having been made by the family physician. The child was extremely thin and pale, walked with a staggering gait, and swallowed with great difficulty. Its speech was incomprehensible, and the muscles of the neck were so weak that, when seated, the child was obliged to support its head with its hands. The diagnosis was correctly made by Gosselin, proper treatment instituted, and in six weeks the child was well. It is important, with reference to prognosis, to determine whether the lesion is entirely peripheral or whether, in addition to the neuritis, the nervous centres are involved. "If, after a stationary period, further symptoms develop, we must believe either that the cause of the disease is renewed . . . or that myelitis has begun. The symptoms of such a myelitis will be an increasing weakness, and more rapid and progressive atrophy of the muscles; a gradually decreasing degree of galvanic excitability in the paralyzed muscles; a loss of pain and temperature senses, which, as a rule, are not affected in neuritis; a decrease in the paræsthesiæ, and an increase in the degree

of anæsthesia, the development of loss of control over the sphincters, the occurrence of bed-sores, furuncles, and eruptions of a bullous nature, and the beginning of cystitis." (" Middleton Goldsmith Lectures," No. 2.)

PROGNOSIS.—In view of the possibility of sudden death from paralysis of the heart, from the entrance of a bolus of food into a patulous and anæsthetic glottis, and from paralysis of the diaphragm, the prognosis should always be guarded; but in the great majority of cases recovery is the rule. Post-diphtheritic paralysis rarely lasts longer than six or eight months, and this fact is in accordance with what is observed in other forms of paralysis dependent upon peripheral neuritis. In rare instances the duration has been much greater. Thus Bailly, in his thesis, refers to the case of a young girl who was attacked with diphtheria at the age of nine, and still spoke with a nasal intonation, "*un léger nasonnement*," nine years after. In another case there was persistent aphonia. There can be no doubt that, in such cases, the lesions are central as well as peripheral.

TREATMENT.—The fact that recovery from diphtheritic paralysis is the rule does not warrant its treatment by the expectant method. Much may be done to hasten recovery by proper therapeutic methods. Internally, strychnia, arsenic, and iron are the drugs from which the best results have been obtained. Strychnia, as advised by Starr, may be given in doses of one-sixtieth to one-twentieth grain, ter in die, and may be combined with phosphoric acid and syrup of the hypophosphites; arsenic, in doses of one-fiftieth to one-thirtieth grain, or in the form of Fowler's solution, five minims after each meal. Iron is indicated when anæmia is present. Locally, warm baths, massage, and electricity must be systematically employed. The bath is best given at night, before retiring, and is more efficacious in securing sleep than any so-called hypnotic. Massage should be administered daily, unless contra-indicated by excessive hyperæsthesia. Electricity should be used in the form of the continuous and broken galvanic currents, and faradization should also be employed when the paralyzed muscles respond to it. The continuous galvanic current is believed to hasten the process of regeneration in the diseased nerves. It should be used of a strength not exceeding twenty milliampères. Starr points out that the current grows stronger during the application, on account of the diminishing resistance of the skin, and therefore, "if the strength is measured in cells, the number of cells used should be decreased gradually during the application." The nutrition of the muscles is promoted by their passive contraction. If degenerated, they will not respond to the faradic current, and therefore the interrupted galvanic current must be employed. "The pole which produces a contraction with the least current possible is the one to be applied to the muscle." The improvement may be measured by the use of the galvanometer.

Frederick P. Henry.

PARALYSIS, INFANTILE SPINAL. Under this name we recognize a form of paralysis which occurs, as the name implies, most frequently in young children, especially during the period of first dentition. It is by far the most common form of paralysis to which children are subject and presents a well-marked clinical picture. A healthy child is suddenly found to have lost the use of one or more extremities, or of some individual muscle of an extremity. This loss of power may or may not have been preceded or accompanied by febrile disturbance; occasionally convulsions have ushered in the paralysis, but never is the latter accompanied by loss of sensibility. Any of the voluntary muscles of the limbs or trunk may be affected, but the functions of the bladder and rectum are left undisturbed. Such is a general description of the onset of the disease. Soon, however, many of the affected muscles begin to recover their power; this recovery may be almost complete, the paralysis being finally limited to a few individual muscles; or, on the other hand, the greater part of the muscles originally affected may remain paralyzed, and later on undergo atrophy and degeneration. In this atrophy and retardation of growth the bones take part, giving rise to shortening of the affected extremity, while other deformities occur as a result of the unopposed action of the healthy antagonists of the disabled muscles.

Synonyms are numerous, and owe their variety to the views held by different observers as to the nature of the disease, before its pathology had been established. They are: Infantile spinal paralysis; Spinale Kinderlähmung (Jacob v. Heine); Paralysie spinale; Paralysis infantilis spinalis; Infantile paralysis; Kinderlähmung; Paralysie infantile; Paralysie des petits enfants; Essential idiopathic or functional paralysis of children; Paralysie essentielle de l'enfance (Rilliet and Barthez); Essentielle Kinderlähmung; Dental paralysis (Underwood, 1784); Poliomyelitis anterior acuta; Acute inflammation of the anterior gray horns of the spinal cord (Kussmaul); Tephromyélite antérieure aiguë (Charcot); Acute atrophic spinal paralysis; Paralysie atrophique graisseuse de l'enfance (Duchenne); Regressive paralysis (Barlow). Myelitis of the anterior horns (E. C. Seguin). These various terms were intended by their originators to indicate what appeared to be prominent clinical or pathological characteristics of the disease. Without entering upon the question as to the relative value of a clinical, as compared with a pathological, designation of diseases, there is no doubt that, of all the terms applied to the affection, the best of the first class is that adopted by Heine, Spinale Kinderlähmung, or infantile spinal paralysis. It is true that here even the word spinal would indicate, in a general way, the anatomical location of the lesion which is the cause of the clinical manifestations; but inasmuch as it serves to distinguish this form of paralysis from other paralyses of cerebral origin, we can pardon this slight offence against unity in terminology in consideration of the completeness with which it serves to distinguish the disease. Of the purely pathological terms we should prefer poliomyelitis anterior acuta, as indicating the seat of the lesion, the term acute being especially applicable to the disease as it occurs in children. Seguin's myelitis of the anterior horns purposely omits the term "acute," in order to include the subacute and chronic cases of the disease which sometimes occur in adults. The designation essential or idiopathic paralysis can certainly no longer be applied to a condition which has so well defined a pathology as poliomyelitis anterior; and it seems inexcusable that so excellent a pathologist as Niemeyer should have retained this inaccurate term in the several edition of his work, published in 1867, at a time when the gross lesion had already been demonstrated.

HISTORICAL ACCOUNT.—This disease has in all probability affected children for hundreds of years, without being differentiated by medical writers from other forms of paralysis. As early as 1784, however, Michael Underwood[1] described a form of paraplegia which occurred in teething children, and especially in those suffering from bowel troubles, which in its clinical history resembles the disease now known as infantile spinal paralysis. In 1836 John Badham,[2] of London, described a similar affection occurring in children, which he considered cerebral in origin. Notwithstanding these publications, the condition did not receive general clinical recognition until, in the publication of J. v. Heine's[3] great monograph, entitled "Beobachtungen über Lähmungszustände der unteren Extremitäten und deren Behandlung," 1840, the symptom group of the affection was clearly defined and this form of paralysis distinguished from other forms of paralysis occurring in children. The picture of the affection in question, which Heine gives us in the very first edition of his work, is so accurate in detail that later clinicians had but little to add to the symptomatology of the disease. But, although no objective or subjective manifestation of the disease escaped the notice of this accurate observer, yet he remained ignorant as to the true pathogenesis of the affection. So logical a mind, however, could not but suspect that the disease was the result of an actual lesion of the nervous system, and accordingly we find him indicating the spinal cord as the most probable seat of the lesion. In the second revised edition of his work[4] he terms the disease Spinale Kinderlähmung, or

Infantile Spinal Paralysis. Duchenne, de Boulogne,[5] in 1855, besides accurately describing the affection, took a great stride in the direction of precision in diagnosis as to the character and extent of the paralysis, by discovering the relation which the faradic current bears to muscles which are the seat of this paralysis. Here, then, the first stage in the history of the disease may be said to have been completed. But, although clinically the affection was established upon a firm basis, its pathology was yet unknown. Rilliet[6] and Barthez,[7] basing their statement upon negative findings in cases of this disease upon the autopsy-table, considered the affection primarily a muscular one, and hence termed it essential paralysis of children, the term essential referring to the idiopathic or non-organic nature of the paralysis. Although this view gained many followers, and some of eminence, yet it was not long before positive findings upon the autopsy-table exploded this theory as to the pathogenesis of the disease. In 1863 v. Reinecker and v. Recklinghausen[8] published the autopsy of a case in which both lower extremities had been the seat of infantile spinal paralysis. Upon a macroscopic and minute examination of the cord it was found that the ganglion-cells of the anterior gray horns and the nerve-fibres of the antero-lateral columns of that portion of the cord which gave origin to the nerve-fibres supplying the paralyzed extremities had undergone atrophy and degeneration (*Deutsche Klinik*, January 31, 1863). The accuracy of these pathological data was confirmed by similar findings by Cornil,[9] Bouvier and Laborde,[10] Prevost,[11] Lockhart Clarke,[12] and later on by Charcot[13] and Joffroy,[14] Vulpian,[15] Roger and Damaschino,[16] and others. We cannot close this brief historical account of the affection without reference to the studies of Erb,[17] as to the reactions produced by the galvanic current upon the muscles which are the seat of this spinal paralysis. Finally, we should refer to the identity of this affection, as far as the pathology is concerned, to a similar but more chronic affection, occurring in adults, which was first mentioned by Duchenne fils[5a] in 1872, but not thoroughly studied until E. C. Seguin,[18] in 1877, devoted an admirable monograph to the subject.

Pathology.—The anatomical seat of the primary lesion of this form of paralysis is the spinal cord. This has been positively determined by almost forty autopsies. It consists of an inflammatory process, acute in character, affecting in the first instance the anterior horns of gray matter. The lesion is at first diffuse, but as soon as the acuteness of the inflammatory process subsides it becomes limited in its longitudinal extent to circumscribed portions of the cord, in which even at the outset the inflammation had been most intense; this is most apt to be about the cervical and lumbar enlargements. At these points further changes soon occur, the most important of which are destruction and atrophy of the large multipolar ganglion-cells situated in the anterior cornua.

This destruction and atrophy are not limited to the cells, but involve the nerve-fibres in this region, and even the cells and nerve-fibres of the posterior horns may become involved; sometimes the lesion extends into the white substance of the antero-lateral columns. As a result of the primary lesion in the ganglionic cells of the anterior gray cornua, we have secondary changes taking place in the nerves which take their origin from the affected portion of the cord, and in the muscles to which these nerves are distributed. These changes are atrophic and degenerative in character.

Spinal Cord.—There are no autopsies showing the condition of the spinal cord during the acute stage of infantile paralysis, inasmuch as the disease of itself is rarely, if ever, fatal. We can therefore make no positive statement as to the condition of the nerve-centres during this acute stage; we can conclude, however, from our findings later on, that the disease is, in the first instance, an acute parenchymatous inflammation affecting chiefly the ganglion-cells of the anterior horns of gray matter in the cord (Charcot).[19] When the autopsy has been made within two years after the onset of the disease, but slight changes can be observed in the cord by the naked eye, although the microscope reveals decided and constant alterations. These changes are typically shown in a case examined by Dr. Fred. Taylor, the particulars of which were presented to the London Pathological Society. It was that of a girl, three years of age, who suddenly became paralyzed, at the age of fifteen months, in the left leg. The paralysis was supposed by the friends to be the result of a blow; the principal symptoms observed at the time of the onset were fever and pain in the left lower extremity, followed by paralysis, and, later on, the development in the paralyzed member of the ordinary clinical phenomena of infantile spinal paralysis. The child was treated by galvanism for five or six months, and the paralysis somewhat improved; but at the age of three years death resulted from broncho-pneumonia. Post-mortem examination of the spinal cord showed a diminution in the size of the transverse section of the left half of the lumbar region of the cord. This diminution was most marked anteriorly, although also observable in the left posterior horn of gray matter. The anterior roots of the spinal nerves at this level were smaller than the corresponding roots on the right side. The posterior nerve-roots were unaffected. On microscopical examination of a section taken from this portion of the cord it was found that there were but few ganglion-cells in the left anterior cornu, and even those remaining were ill-defined and smaller in size, paler in color, and possessing fewer and shorter processes than those on the right side. The absence of these cells was most marked in the external and median group of ganglion-cells.

The nerve-fibres passing from the anterior root to the cornu of the affected side, were diminished in number and size. The main substance of the anterior horn consisted of a very dense and felt-like tissue, made up of matted fibres, "an increase and condensation of the normally open and spongy basis-structure of the part." In this felt-like structure the remaining nerve-cells were embedded; no granular corpuscles were visible. The white matter of the left antero-lateral column was found denser, the connective tissue being increased; while the nerve-tubules were smaller than usual and deficient in axis cylinders.

This case shows the most prominent changes found in the cord in cases in which the autopsy has been made comparatively early. Occasionally areas of softening are found, more or less well defined, in different portions of the anterior horns, and at such places there is generally a total absence of proper nerve-tissue, ganglion-cells, and nerve-fibres; but instead there is a low form of connective tissue, filled with large numbers of leucocytes and simple nuclei. In these recent cases the blood-vessels are found dilated. The cord may be affected at any level, although the cervical and lumbar regions are most frequently the seat of permanent lesion. The severity of the inflammatory process varies greatly, so that in some situations there is almost complete recovery, while in other places there is utter destruction, degeneration, and atrophy of nerve-cells and fibres. The ganglion-cells have been found in all stages of various forms of degeneration; many of them are entirely destroyed, and those that remain are found in a condition of extreme atrophy, having suffered great contraction and diminution in size, the cell processes, and frequently their nuclei, being destroyed. Sometimes the atrophy is of the pigmentary variety. In a case reported by Dr. Humphreys,[20] of Manchester, the number of the polar cells remaining in the affected portion of the anterior horns was compared with the number in the corresponding healthy portion of the cord, and it was found that while on the healthy side there were fifty-two ganglion-cells, on the diseased side there were but thirteen.

Should the autopsy be made, as more frequently happens, many years after the original lesion has taken place, we would find changes similar in character to those described, but further advanced in a retrograde direction. The changes can be admirably studied in a collection of autopsies reported by Seguin in his work, and quoted and amplified by Seligmüller in his article on this subject in Gerhard's large work on "Diseases of Children."

These changes are now readily appreciated by the unaided eye. The affected portion of the gray anterior horn is apt to be markedly shrunken and atrophied; sometimes even the posterior gray horns will be found slightly smaller than on the opposite side. The white columns, and especially the antero-lateral columns, are found atrophied and sclerosed, sometimes to a limited extent on a level with the lesion, at other times to some distance above and below the lesion; indeed, the transverse section of the cord in the affected side will show a general diminution in size as compared with that of the healthy side. The anterior nerve-roots at the level of the lesion are apt to present a grayish, translucent appearance, and a diminution in size.

The microscope also shows the more complete atrophic changes which the nerve-tissue has undergone: the diseased portion of the atrophied anterior horn is found to contain but few or no multipolar ganglion-cells, and even those remaining are shrunken, with their processes atrophied, and found to have undergone various stages of granular and pigmentary degeneration. These cells have been replaced by connective tissue which has become contracted and hardened.

The changes in the white columns are apt to be less marked, although, as already stated, there is some diminution in the size of the antero-lateral column, to a greater or less extent, above and below the lesion. These changes can scarcely be termed sclerosis. They consist of a certain degree of hyperplasia and contraction of the connective tissue, and an increase of the nuclei of the neuroglia. Amyloid corpuscles are also found. The anterior nerve-roots undergo a more decided atrophy than the antero-lateral columns; the number of their medullated nerve-fibres is decidedly diminished. Many of them have lost their myeline, leaving only the axis cylinders, and, as a whole, the nerve-root has become thinner, and of a grayish and translucent appearance. The diseased foci in the gray matter are apt to be quite sharply defined, although at the onset of the disease large portions of the cord, above and below the areas of softening, are found congested; these portions, however, are not the seat of destructive changes, and they recover as soon as the inflammatory process subsides. This probably corresponds to the regression which occurs in the symptoms, thus leaving only those muscles paralyzed which derive their nerve-supply from the softened areas. (For diagrams, see Hammond's from Charcot.)

Changes in the Paralyzed Muscles.—Within a few weeks after the paralysis has taken place the paralyzed muscles become the seat of characteristic pathological alterations; not only do they become atrophied and smaller in size, owing to disuse, but they undergo active degeneration. Portions of such muscles can be obtained for examination by means of an apparatus like Duchenne's trocar, so that the various stages of degeneration can be studied. The first stage in the degeneration is, undoubtedly, ordinary atrophy of the muscle-fibres. The fibres are narrower and diminished in diameter, the transverse as well as the longitudinal striations are finer and apparently more numerous. This apparent increase in the number of the transverse striations is due to the diminished thickness of the contractile disks. These phenomena are seen in muscles that have become atrophied from disuse, and are not distinctive of atrophy due to spinal cord lesions.

In infantile spinal paralysis, however, the muscles soon begin to show further changes. Certain portions of the degenerating muscles begin to loose their striations entirely; here and there we find contractile disks replaced by granular matter, until the whole fibre has become to a great extent granular. This granular matter is probably protein in character, being at first soluble in acetic acid and insoluble in ether; later on, however, the granules are found to be insoluble in acetic acid and soluble in ether, which shows that the protein granules have been replaced by fatty matter. Here and there will be found pigment granules. The muscle-corpuscles are found to have increased in number, and in fibres which have undergone a complete granular fatty degeneration we shall find no trace of proper muscular tissue, the fibres being replaced by these muscle-corpuscles embedded in a mass of fat granules surrounded by the sarcolemma. This may be termed complete muscular degeneration, and is the inevitable fate of muscles which have not recovered in the earlier stages of ordinary atrophy. Some of the muscles thus degenerated become the seat of further changes. The connective-tissue corpuscles found in the endomysium and perimysium increase largely in number, and form themselves into fibrous connective-tissue bands, which compress the degenerated muscular fibres; gradually the fat is absorbed, and what was formerly muscular tissue has become a firm fibrous cord. This change is known as cirrhosis of the muscles, and does not occur until long after the muscles have undergone hopeless degeneration. These fibrous bands are apt to undergo contracture, which results in structural shortening and deformity. Rarely the connective-tissue corpuscles, contained in the fibrous bands, in their turn become distended with fat, thus giving rise to a deceptive fulness instead of the previous atrophy. This second fatty deposit may be so great as to lead to a diagnosis of pseudo-hypertrophic paralysis. When such a deposit of fat does occur it is in infantile paralysis of long standing. The ligaments and bony structures also take part in the general lowering of vitality which characterizes the paralyzed limb. The bones do not grow with anything like the vigor of the corresponding bones on the healthy side. This retarded growth results in diminution in the length as well as in the thickness of the bone; the prominences, ridges, etc., are less marked; the bone is more readily bent; closer examination shows that the compact tissue is relatively diminished, while the cancellous tissue is coarser and has scattered through it a larger number of fat-cells. The bones are thus softer, but microscopically no changes in the structure of the bone-tissue are found. All this results in a weakening as well as a shortening of the bone, and, necessarily, of the limb. Seeligmüller considers this bony change mostly the result of the disuse which is necessarily connected with the paralyzed member; the fact, however, that these atrophic bone changes are noticed in limbs in which the paralysis is insufficient to interfere with the adequate use of the member, would militate against this view, apart from the fact that the changes indicated seem to be far more radical than would be accounted for by ordinary functional atrophy due to disuse.

Partly in consequence of this bone atrophy, and partly as a result of the relaxation of the ligaments and muscles, the joints are apt to become altered. In extreme cases the ends of the bones which form the joint are not in contact, but hang apart from each other, so that the finger can almost invaginate the skin and ligaments between the joint surfaces. As a result, the articulation admits of abnormal mobility—motion resulting in subluxation of one joint surface upon the other. These changes are most readily observed where a muscle which passes over a joint is more or less completely paralyzed; thus, when the deltoid is paralyzed in the arm, the shoulder-joint is apt to show the above-mentioned changes very markedly. No pathological changes have been observed in any other organs of the body.

Etiology.—Poliomyelitis anterior acuta is no exception to the rule in the obscurity of its etiological chapter. We know little or nothing as to the causes which produce the disease. We must, therefore, satisfy ourselves with an inquiry as to the causal relation borne by certain conditions, which precede the appearance of the paralysis, to the more or less acute inflammatory process in the anterior horns of the spinal cord. Before proceeding to this study there are certain factors which can be eliminated, and thus limit the field of inquiry.

Infantile spinal paralysis is by far the most frequent form of paralysis to which children are subject. Jacob v. Heine found, among 192 paralyzed children, 158 suffering from this disease.

The disease in its acute form is peculiar to childhood, and is most frequent in the first, second, and third years of infant life. Duchenne the younger has noted one case occurring at the early age of twelve days. Seeligmüller

has noted the oldest of his seventy-one cases as six years, but almost ninety per cent. of all cases reported were under three years of age. Sex is not a predisposing cause, the sexes being affected with about equal frequency.

The disease is found all over the civilized world, so that climate can scarcely be considered as exerting a predisposing influence, nor does the season of the year make any difference, cases occurring indiscriminately at all seasons. Wharton Sinkler (*Amer. Journal of Med. Sciences*, April, 1878) states, however, that 47 out of 57 cases occurred in the warm months of the year.

Heine has stated that the disease most frequently affects strong, healthy children; and, indeed, one who sees many of these cases cannot fail to have observed many large, robust, little patients, whose otherwise handsome physique has been deformed by an attack of poliomyelitis anterior. But, on the other hand, most observers find that the majority of cases occur in children who are weak and delicate, even if a strumous constitution cannot generally be affirmed of them.

One of the most frequent causes, assigned by mothers, for this disease is "catching cold," particularly exposure to the direct action of a "draught." Or another very common cause, as stated by the parents, is a fall from the arms of the nurse or from a chair. Whether a traumatism of this kind can give rise to infantile spinal paralysis proper is questionable. It is conceivable that spinal paralysis, resulting from hæmorrhage into the gray matter of the cord, may follow a traumatism, but this is not poliomyelitis anterior, although the clinical symptoms may be those of the latter disease, and it may be impossible to differentiate these cases from those of inflammatory origin.[20]

The disease being one of the first dentition period, it is natural to look to conditions connected with this process for etiological factors in its production.

There is no question that the process of dentition throws the nervous system of the child into a state of exalted irritability, during which eclampsia, tetanus, and other neuroses are commonly observed. These nervous phenomena are chiefly conditions of exalted nervous irritability, in which it is conceivable that the gray ganglion cells of the cord take part. From this irritated condition it is only a step to inflammation. Henry Kennedy has called this disease dental paralysis (*Dublin Quarterly Journal*, vol. ix., February and May, and vol. xxii., August and November). The restlessness of children while teething, the disturbed nutrition, want of sleep, and febrile disturbances common to this period of life, all are sufficient to render the spinal cord more sensitive to slight active causes, such as refrigeration, etc.

It may be objected, however, that all of these influences would affect the spinal cord as a whole, while in this disease only the anterior gray columns of the spinal cord are primarily affected. This might be explained by reference to the fact that motor areas of the cord in infants are much more in demand, and further developed than the sensory tract. Infants are in constant motion, the extremities are thrown about whether in health or disease; during the waking hours infants constantly move and throw about the limbs and body; as a result the centres for these movements are supplied with an excess of blood, and hence are more prone to take on inflammatory processes.

Acute febrile conditions are commonly assigned as causes for this disease. It must not be forgotten, however, that the disease is in very many cases ushered in by fever, which is a symptom of the inflammation, and cannot be considered an etiological factor. But there are many cases which occur during the course of, or follow upon, the acute exanthemata—scarlet fever, measles, and typhoid fever. Such cases must be carefully distinguished from post-diphtheritic paralysis, the more so since diphtheria often complicates scarlet fever, measles, etc. Duchenne and Seeligmüller report two cases following upon vaccination.

In many of the cases careful inquiry into the family history of the patient will reveal the existence of nervous affections in other members of the same family—either paralysis, convulsions, or insanity. Thus I have seen infantile spinal paralysis of the leg in a little girl, and paralysis of the upper arm in a younger brother of the first patient.

Symptomatology.—In discussing the symptoms of this disease it is perhaps wise to take up in order the characteristics of the invasion, the appearance of the paralysis, and lastly, the deformities and contractures resulting from the paralysis.

First, the Stage of Invasion.—Although various prodromal symptoms have been laid down in the text-books as preceding the onset of the disease, yet none of these appears to me to be peculiar to this affection, even in slight degree. The children are irritable, slightly feverish, and suffer from loss of appetite; the bowels are constipated or relaxed; some of the little patients complain of pains in the back and limbs. One observer[21] has noted that these patients refuse to walk, or, if they walk, are easily made tired and wish to be carried. I myself have not noticed the latter symptom as part of the history of my cases, and have found very many cases—indeed, the large majority of my cases—in which no prodromal symptoms at all occurred. Cases may be divided, as regards the character of the invasion, into two classes: First, those in which the onset is shown by high fever, with or without convulsions; second, those in which the stage of invasion is entirely absent, the patient becoming suddenly paralyzed.

Cases belonging to the first class will be found to have either the febrile disturbance or the nervous symptoms most prominent. The patient is suddenly attacked by high fever, 100° to 102°, or 103°, rarely above; there are great thirst and restlessness. At the beginning of this fever there may occur a convulsion lasting a short time, and often followed by others, or the fever may be slight; but the child lies in a state of semi-coma for a few days, from which it gradually rallies, when the friends find one or more groups of muscles, or one or more limbs, paralyzed. The fever may last from a few hours to two or three, or even more, days; but, as a rule, it continues only a few days, after which it subsides, and the parents believe the child to be on the road to recovery. Then suddenly paralysis is discovered to have taken place. If the paralysis is slight, it may not be noticed until the initial fever has long passed, so that the parents will assure the physician that there was no fever before the onset of the paralysis.

In cases occurring during the course of convalescence from measles or some other acute febrile affection, the paralysis is supposed by the friends to be due to the general disease.

In many of the cases, in addition to the fever, with or without convulsions or semi-coma, the patients suffer from diarrhœa, and often vomiting. Hyperæsthesia of the limbs and other portions of the body may also occur. There may be frequent micturition, but there is never paralysis of the bladder or loss of sensation.

The cause of the initial fever would appear to be the acuteness of the inflammatory process in the cord. W. Vogt,[22] however, considers the lesion in the cord a result, rather than a cause, of the fever. The fever is not a constant accompaniment of this disease; it was present in about one-half of my cases. Frequently parents do not notice the fever, which may occur at night, when the child is asleep. When the little one awakes in the morning the paralysis is observed, although the fever, if only of a few hours' duration, may have been overlooked. The antecedent fever is noted, however, in the cases in which it is of longer duration. It has been known to last for twelve days; but in most cases it is of less than two days' duration, and commonly lasts only twenty-four hours. The temperature rarely rises above 103°, or, at most, 104°, and even these figures are exceptionally high. We have no good thermometric records; the diagnosis being never possible before paralysis has set in, and the fever has, as a rule, come to an end, although cases have been reported in which the fever lasted after the paralysis was complete.

Convulsions occur, in the opening stage of this dis-

case in many cases in which fever is present, and also in some in which there is no rise of temperature. This would seem to prove that the convulsions are not dependent upon the cerebral hyperæmia produced by the fever. It is, furthermore, not probable that these attacks, which are epileptiform in character, are due to lesions in the spinal cord, for the muscles which become convulsed are not only those that are afterward found to be paralyzed, but impartially those of the whole body. Some writers, however, state that the convulsive movements are more violent in those muscles which afterward become paralyzed. The attacks vary in duration, number, and frequency. Frequently only a single convulsion ushers in the disease; at other times the patient is thrown into a status epilepticus lasting some hours, and it is conceivable that in this condition the patient may die, the diagnosis of poliomyelitis not having been made. On the other hand, the convulsion may be so slight as to be entirely overlooked, and, if it take place during the night, the fever as well as the convulsion may be entirely overlooked. The recovery from the convulsion may be complete, or the child may fall into a stupor, and even coma, from which it only emerges when all acute symptoms have disappeared. Frequently the little patient has no convulsions, but still is restless and trembling, or apathetic and drowsy. Either of these conditions may be present in the opening stage of the disease, with or without the fever.

Another symptom, to which we must call attention, is one which accompanies all febrile conditions, but is here particularly prominent, namely, hypersensibility—the patient cannot be touched without feeling pain—he cannot be moved without crying out. Some writers have stated that this exalted sensibility is most marked in the spinal column. My own experience does not show that the little patients ever complain of a sensitive spine. On the contrary, I have found these children very easily handled, and the spine very flexible, this fact forming one of the data for the differential diagnosis between this disease and Pott's paraplegia, although patients may have passed through the initial stage of the malady with more or less of the above symptoms, or so little of them as to escape the observation of the friends; yet the

Second, or paralytic stage, is never omitted, and is, in fact, "the disease" (Rilliet and Barthez). The paralysis may develop very suddenly, the child being paralyzed almost as rapidly as though from apoplexy, or may develop more slowly, the paralysis gradually extending in the course of one, two, or three days. In the first class of cases a large number of the voluntary muscles of one or more limbs become paralyzed simultaneously; in the second class of cases the paralysis extends from one group to another until the maximum paralysis has been attained. Sometimes the paralysis is so complete that the patient lies without being able to move a muscle. At other times the paralysis is so slight that it is unnoticed until the function of the paralyzed member is interfered with.

However complete the paralysis at first may be, yet it is characteristic of this disease that after a short time (one or more days) many of the paralyzed muscles begin spontaneously to recover their power; this is known as the regression of the paralysis. Spontaneous recovery from the original paralysis may be complete in certain individual muscles, although entire recovery for all the muscles never occurs. Many writers state that in most cases the height of the paralysis is attained at the end of twenty-four hours. My experience leads me to give a longer period for the development of the palsy, certainly not longer than a few days, when the paralysis will cease to extend. Regression, however, begins in many cases as early as the second day, continues rapidly for the first few weeks, then much more slowly, although even up to four or five months the muscles may still undergo spontaneous recovery of power. Any power restored after that is due either to the good effects of treatment or to the use of the limb. However complete the restoration of some of the paralyzed muscles may be, it may be positively affirmed that complete recovery in all the muscles affected by infantile paralysis is impossible.

Muscles Affected: All the voluntary muscles of the body may be the seat of this paralysis, except those of the head (Seeligmüller reports one case in which the muscles supplied by the facial were affected), eyes, ears, mouth, pharynx, and larynx. On the other hand, the sterno-cleido-mastoid has been found affected, the muscles of the trunk, including those of the back and abdomen, and, above all, the muscles of the extremities.

The paralysis may affect the back so that the patient cannot sit or stand; the neck, so that the head falls forward or to the side, and it may affect one or more extremities, giving rise either to crossed paralysis (one arm and the opposite leg), or paraplegia (all four extremities or the two lower extremities), both upper extremities or the arm and leg of the same side (hemiplegia).

Most frequently only one extremity is affected. Next in order of frequency comes paralysis of both lower extremities, while crossed paralysis and hemiplegia are much rarer. The upper extremity is less frequently affected than the lower, while paralysis of all four extremities is extremely rare, but three cases having been reported in the literature (see Seeligmüller).

It is extremely rare for a limb to remain totally paralyzed, nor do we find in any two cases an exactly similar distribution of the paralysis.

Certain groups of muscles will be found to have escaped the paralysis, and sometimes even portions of the same muscle will retain power, while the rest of the muscle is paralyzed.

The anterior tibial group of the leg and the extensors of the thigh are most frequently affected. The psoas, on the other hand, is rarely affected, even in the most extensive paralysis.

In the upper extremity the deltoid is most frequently paralyzed.

The sphincters of the bladder and rectum are never affected. In this respect we have an important difference between this form of paralysis and that following transverse myelitis. It is true that in some very young children the general disturbance with which the disease is ushered in may give rise to a few involuntary passages, but this is only temporary, and will not be present when the paralytic stage has set in. After the sixth to the ninth month has passed, we can no longer look forward to spontaneous recovery in the paralyzed muscles. Muscles which have not improved until then are apt to remain paralyzed, and go on to the third stage of the disease, the atrophic stage, in which extreme atrophy of the paralyzed muscles is the most prominent symptom. It must not be supposed, however, that the paralyzed muscles do not atrophy until six or more months after they have become the seat of the paralysis. On the contrary, atrophy of the fibres of the paralyzed muscles can be found with the microscope very soon (two or three weeks) after the paralysis has set in, and several authorities claim to have observed atrophy, evident to the naked eye, as early as the third week after the paralysis. In my own cases I do not remember to have observed any evident atrophy earlier than three months after the first occurrence of the paralysis. The cause of this atrophy is, as we have already seen under the head of pathology, not simple disuse of the paralyzed limb, but a cutting off of the trophic influence of the nerve-cells of the anterior gray horns of the spinal cord; this results in a disturbance of the nutrition of the muscle tissue as well as organic degeneration of the nerve-fibres. Disuse of the paralyzed limb undoubtedly aids in producing a diminution in the size of the paralyzed member. As a result of these causes we have a very extensive atrophy of the paralyzed muscles—so complete that frequently the configuration of the bones, with their anatomical points, can be felt or even seen with startling distinctness. Often all muscular tissue seems to have disappeared, leaving only the bones, connective-tissue bands, and skin. As already explained, however, these atrophic members in the last stages of atrophy may undergo a pseudo-hypertrophy, owing to the deposit of fat in place of the atrophied muscle-fibres. In those muscles that undergo recovery after a certain amount of atrophy has

taken place, the restoration of volume in the recovered muscle does not directly follow upon restoration to power. The muscle is only gradually restored to its former size some time after power has returned.

Atrophy is not limited to the paralyzed muscles, but affects the bones and ligaments, and even the blood-vessels; the extent and character of the atrophic changes have already been discussed. There is also atrophy of the skin; it is apt to be more delicate and thinner; it is of finer texture, and paler in color at first, although later on it becomes cyanotic in color, owing to the diminished blood-supply in the paralyzed limb. This diminished blood-supply is due to atrophy of the blood-vessels and the disappearance of the finer capillaries. The muscular coat of the arteries is atrophied, giving rise to a diminished arterial tension. In consequence of this diminished blood-supply the surface temperature of the paralyzed member becomes greatly diminished. Fluctuation in temperature is very great, especially when the body has been exposed to cold. Thus the difference between the healthy and paralyzed limbs may be 20°, 30°, or even 40° F. It is almost impossible to keep the paralyzed limbs warm; friction and artificial heat serve to restore warmth for a time, but unless frequently applied do very little good. As a result of the lowered temperature and slowness of circulation, the skin sometimes becomes the seat of ulcerations, which are very slow to heal, and are exceedingly painful. These ulcers affect only the scarfskin, and consist of a desquamation of the epidermis, the derma remaining unaffected. As part of the symptomatology of the paralytic and atrophic stage of the disease, we must devote some space to the discussion of the accompaniments and results of both of these conditions, namely, the deformities so characteristic of the final stages of this affection.

Third, Deformities Resulting from Infantile Spinal Paralysis.—A careful analysis of the deformities resulting from infantile paralysis will warrant their classification into two groups.

1. Deformities due to trophic changes in the limbs.
2. Deformities depending on the paralysis of muscles.

1. Deformities Due to Trophic Changes. In discussing the symptomatology of this disease, it was seen that, owing to destruction or interference with the trophic centres in the cord, all growth of the parts supplied by the nerves passing from the affected region was arrested, and the development which the affected tissues had attained before the time of seizure was diminished, the tissues retrograding and undergoing degenerative changes. The deformities of this group, then, are due, first, to cessation of growth; second, to retrograde metamorphosis. Cessation of growth is in every direction, and results in shortening and attenuation of the affected member as compared with the condition of the limb in health. Retrograde metamorphosis or atrophy will also cause deformity, either by shortening, or, more commonly, by attenuation; so that lack of growth, aided and reinforced by atrophy and degeneration, results in deformity by producing shortening or attenuation, or both together. From a consideration of the function of the upper, as compared with the lower, extremity of the body, it is evident that deformity due to shortening is of far more importance when it affects the lower extremity than when it affects the upper. Not only is it essential that the two limbs should be of equal length in order that the patient may walk and stand without deformity, but the proper performance of the functions of other parts of the body depends upon the lower extremities being of equal length. For, the trunk being supported by the two lower extremities acting as pillars, the shortening of one of these pillars as compared with the other will result in a corresponding lowering or sagging of that side of the body; the pelvis will become oblique, the normal side being on a higher plane; and were it not that conservative nature seeks to rectify the result of the disease, we should see these patients walking and standing with the body bent over to the side of the shortened leg. To maintain equilibrium the patient is compelled to throw the body to the opposite side, giving rise to a functional lateral curvature of the spine, which, in its turn, again in the effort to maintain equilibrium, is modified by a secondary curve. We have, then, as a result of the shortening of the lower extremity, deformity in walking and functional lateral curvature.

Atrophy and attenuation are of less importance here than in the upper extremity, disability rarely resulting from this cause alone; while, on the other hand, shortening is of less importance in the upper extremity than in the lower; for one arm or hand may be shorter than the opposing member, but were it not for the paralysis which accompanies the shortening, it would be of little importance. On the other hand, atrophy is of great importance in its effects upon the upper extremity. An atrophic shoulder will sag downward, producing even, in some cases, a lateral curvature high up. But what is more common, the head of the humerus becoming atrophied, and the hand having no resistance below, as is the case with the foot, we have a resulting subluxation, which in itself would interfere with the use of the arm. In one of my cases this subluxation in every direction resulted from the slightest motion, and was an important element in the treatment of the case. Although, in the limits of this article, I consider it more profitable to indicate the *principles* which govern the production of deformities which result from infantile spinal paralysis, rather than to minutely catalogue all of these, I cannot here overlook a seemingly minor deformity which results from the muscular atrophy characteristic of this disease. I refer to the undue prominence of the articular extremities of the bones in cases in which the muscular atrophy has become extreme. This deformity is so marked in some cases as to lead the patients to believe that the joints are dislocated, or are the seat of osteophytic growths. Although this undue prominence of the extremities of the bones does not interfere with locomotion, yet it is of great importance in the treatment of these cases; for a careless application of rigid orthopedic apparatus often results in the formation of callosities over these bony surfaces which are painful to the patient, and when once formed are difficult of removal.

The second group of deformities which result from this disease are by far the most important; they are the deformities depending upon the paralysis of muscles. Inasmuch as individual cases differ greatly as to the extent of the paralysis and the number of muscles involved, so also the variety of deformities resulting from infantile paralysis includes almost every form of inability and perverted motor activity. But before considering these deformities it will be proper to consider the laws upon which their production depends. This subject has been studied by Volkmann in the first of the "Klinische Vorträge." Although inability is the immediate result of paralysis, deformity is not the consequence of the paralysis itself, and does not occur until a later stage of the affection is reached, when it is found that permanent contractures have taken place, of which the paralyzed muscles are generally, but by no means exclusively, the seat. As to the cause of these contractures which so deform the already paralyzed limb, many explanations have been advanced. The oldest and most popular is that of unopposed muscular action. This explanation rests upon the theory that all muscles in their quiescent state are the seat of a reflex tonicity. That is to say, it is supposed that the higher centres of the brain and spinal cord are constantly sending out innumerable and minute impulses in response to constant and unconscious peripheral excitation. This constant state of contractility is known as the reflex tonicity of the muscles, and being constantly present in all of the voluntary muscles, the parts moved by them are kept at rest except when the will or reflex causes throw excess of energy into any single group. The principle is similar to that by which the heavenly bodies are enabled to retain their places in the universe, although constantly acted upon by centrifugal and centripetal forces.

Reasoning from this assumption, it is supposed that as soon as any group of muscles is cut off from the motor

centres in the cord, the opponents, being still the seat of the normal muscular tonus, undergo contracture because the equilibrium has been destroyed. Were such the explanation, however, we should expect immediately after the paralysis to see the remaining healthy muscles become permanently contractured. Volkmann did great service in combating this theory, although he has gone to the opposite extreme and proposed one almost equally untenable. He found that in children with infantile paralysis of all of the muscles of the lower extremity, in which the muscular groups on the anterior as well as those on the posterior portion, or calf of the leg, were paralyzed, the tendo Achillis was the seat of contracture, and the foot assumed the equinus position, just as though the anterior tibial group alone had been paralyzed and the calf muscles had remained intact. Again, in cases of talipes equinus, immediately after the performance of tenotomy of the tendo Achillis, if the child were placed in a chair with the legs pendent, the foot, instead of assuming the calcaneus position, in obedience to the unopposed action of the anterior tibial group, is found to place itself in the equinus position; this is explained by the action of the force of gravity upon the foot. On the strength of both of these observations he explains the production of the deformity in many cases by the action of the force of gravity, claiming that the position which this force compels the paralyzed limb to assume, as the patient sits or stands, will be the position in which contractures will most frequently fix the limb. But on consideration we find that, even in the extremity on which the force of gravity is most influential, namely, the foot, this theory is not substantiated; for which one of us has not seen an acquired talipes calcaneus with toes raised and heels bulbous and boring the ground. The study of a recent case of facial paralysis will help to clear up this subject.

It will be found that after the paralysis has occurred, as soon as the patient has made the first use of the non-paralyzed side, the face is slightly drawn to the healthy side. I say slightly, not so completely as it would necessarily be if the cause of the deviation were the unopposed action of the healthy side, but just enough to make it noticeable. This deviation, I think, can be explained in the following manner: The first facial motor impulse that occurred immediately after the paralysis had taken place, found only the healthy side of the face ready to act. It contracted, and as soon as the motor impulse ceased the tissues returned to their relaxed condition; this passive relaxation is almost, if not quite, sufficient to restore the tissues to the position they occupied before contraction. The residual work necessary to complete the restoration the opposing muscles do for each other, and since in our supposititious case the opponent was paralyzed, the healthy muscles had almost, but not quite, returned to their normal position. In other words, the origin and insertion of the muscles have been brought slightly nearer to each other than they should be normally in the condition of rest with increased activity. After a time the shortening will become more marked, and the muscle will assume the contractured appearance so familiar in deformities following long-standing paralysis. The paralyzed muscles, in order to adapt themselves to the contracture and shortening of the healthy muscles, become passively stretched, for it is evident that every time the activity of the healthy muscles is called into play the paralyzed opponent is stretched and becomes longer, just as the healthy muscle becomes shorter. The contracture or shortening of the healthy muscles, which is primarily the result of the use of the healthy muscles, is increased by, and at the same time the cause of, the elongation which the paralyzed muscles undergo. I conceive that the only contractures which are properly the result of the action of gravity are those in which all the muscles of the limb are paralyzed, and in these cases there is no question of the non-applicability of the theory of muscular tonicity. There is another form of contracture of which the paralyzed muscles themselves are sometimes the seat; this is the result of the final stage of atrophy which the paralyzed muscle undergoes. Then the muscular fibres disappear, the muscles proper being replaced by connective tissue bands, these contract, and when such contractures occur they counteract other previous contractures of the non-paralyzed muscles.

It follows, then, that paralysis of muscles causes deformity in one of two ways: first, by mere inability resulting from the paralysis; second, by the resulting contractures in the healthy or paralyzed muscles.

Deformities of the lower extremities. Extensive paralysis, involving all of the muscles of the lower extremity, will produce a deformity well described as "flail-like." Here the lower extremity is so flaccid, and the patient has so little command over it, that in walking (with crutches) it swings as loosely as a flail; and yet, however complete the paralysis may be, careful examination will show here and there a muscular group of which the patient has retained the use. The psoas magnus is frequently preserved, so that the thigh can be flexed slightly, although the leg cannot be extended. Another very common deformity at the hip joint is inability to extend the thigh because of a contractured psoas. In these cases the hip-joint cannot be extended even to a right line with the body; in cases in which the rectus femoris and tensor vaginæ femoris are preserved this deformity is increased in degree. The prominent tensor vaginæ femoris appears to be so important a factor in the production of the deformity that the effect of the contractured psoas is overlooked. Hence disappointment in the operative and mechanical treatment. When deformity occurs at the knee-joint it is generally due to contracture of the outer and inner hamstring tendons. In these cases the muscles which extend the knee are paralyzed, the ligaments of the knee-joint are weakened by disease, and hence, when the patient attempts to rest the weight of the body upon the knee-joint, it closes up like a jack-knife. When the muscles on both the extensor and flexor side of the thigh are paralyzed, it is impossible to use the knee-joint in standing or walking, and the inability is almost as great as in flail leg. The most common seat of the deformities resulting from this disease is undoubtedly the ankle and medio-tarsal joints; in other words, the joints involved in the various forms of club-foot. The forms of paralytic club-foot conform more or less closely to the classical varieties. The order of their frequency is, in my experience, as follows: 1, talipes equino-varus; 2, talipes calcaneo-valgus; 3, talipes equinus; 4, talipes calcaneus.

Paralysis of both the anterior and posterior calf muscles is apt to result in the equino-varus deformity, that being the position in which the foot is for the most part held. When the anterior tibial group alone is paralyzed, the deformity is apt to be equinus or equino-varus, for reasons already stated. Paralysis of the peronei alone will result in varus. Talipes equinus and equino-varus are often accompanied by contraction of the plantar fascia. This is particularly apt to be the case if the tibialis anticus is preserved, while the rest of the anterior group is paralyzed. Occasionally one or two divisions of the ext. communis digit. remain normal, the rest being paralyzed; the result is contracture of the preserved tendon, and hyper-extension of the first phalanx of the toes supplied by these tendons. In such cases the shoe of the patient presses upon these prominent phalanges, and produces excoriations, thickening, and bunions, which can often be cured only by tenotomy. When the interossei are paralyzed we have a condition analogous to "main en griffe" of the hand, the first phalanx and all of the toes being extended and the ball of the foot prominent. Dr. N. M. Shaffer has described, under the head of "Non-deforming Club Foot," a condition which may be characterized as an incomplete talipes equino-varus; this condition often results from infantile paralysis.

Paralysis of the posterior tibial group, including the gastrocnemius and soleus, will result in calcaneus or calcaneo-valgus, contracture taking place in the anterior group owing to the use of the healthy muscles in a limited arc. These patients walk with the toes raised and

the heel on the ground; this pressure on the heel results in the formation of incurable callosities of the skin, and inflamed bursæ over the os calcis. Deformities of the upper extremities, although far less important than those of the lower extremities, are equally important when we take into consideration the disability which they cause. I have already referred to the inability caused by paralysis of the muscles about the shoulder-joint and the laxity of the ligaments in these cases. But, in addition to the disability, the pectoral muscles and latissimus dorsi become shortened, owing to paralysis of the deltoid, and the arm is held firmly adducted.

Contractures occasionally are found at the wrist and elbow joints, and their production is explicable on the principle already discussed.

In the trunk the most important deformity that can occur is lateral curvature. Not the form due to the shortening of one of the lower extremities, but a paralytic curvature—that is to say, one due to paralysis of the large or extrinsic muscles of the back, or the deep intrinsic muscles of the vertebræ. When the large muscles are paralyzed the corresponding healthy muscles of the opposite side become shorter and cause a bending of the spinal column, composed as it is of flexible segments, to the healthy side, the convexity of the curve looking toward the paralyzed side. If the curve be low down, a secondary or compensatory curve will appear high up. If the primary curve be high up, no secondary curve will be present. This is the result of the necessities of equilibrium. When the deep or intrinsic muscles of the spine are paralyzed, we have, as a result, rotatory lateral curvature, the most deforming condition the orthopedic surgeon has to deal with. The limits of this paper will not admit of the discussion of the cause of the so-called idiopathic cases of lateral curvature; but of the fact that a large number of cases of lateral curvature are the result of infantile spinal paralysis there is no doubt.

Diagnosis of Muscles Affected.—In examining a case of infantile spinal paralysis for the purpose of discovering what muscles are affected, I adopt a plan somewhat as follows: If the patient is able to walk, he should be made to do so while undressed; the movements of the various joints should then be noted and compared with those of the healthy side, any dragging, inversion, or eversion of the leg should be observed. The patient should then assume the recumbent position, and each muscle in turn must be tested as to its activity, beginning with the psoas; the leg may be raised, and the patient requested to maintain it in the raised position; or, if intelligent enough, the patient may be required to perform the action which will bring out the muscle under examination. In infants we are aided in this examination by a condition peculiar to them, by which the limb can be placed in any desired position, and will be retained there if the necessary muscular power is preserved, only gradually falling back to the relaxed state. This peculiarity has been compared to a similar condition present in patients under the influence of catalepsy. Finally, the patient should be examined by the most reliable and accurate test of infantile spinal paralysis, namely, the electric current. In this examination we make use of both the galvanic and faradic currents. We test the degree and kind of excitability of the nerves and muscles to both currents, and compare the result with similar tests made upon corresponding healthy muscles. In speaking of the pathology of this disease it will be remembered that the changes which the nerves and muscles undergo were thoroughly discussed. These changes were of the kind known as degenerative changes. They are not the result of all forms of paralysis, but occur only in those cases in which the lesion which is the cause of the paralysis cuts off the connection between the gray matter (anterior horns in spinal cord, bulbar nuclei in the case of cranial nerves) and the nerves originating therefrom and the muscles supplied by them. The gray matter exerts upon the nerves and muscles what is known as a trophic influence, and it is the loss of this rather mysterious trophic influence which results in the degeneration of the nerves and muscles thus deprived. Paralysis alone does not cause degenerative atrophy, as is shown in cases of cerebral paralysis, in which the nerves and muscles, although deprived of motor power still retain their connection with the so-called trophic centres in the gray horns of the cord.

Muscles and nerves which are the seat of degenerative atrophy give rise to peculiar electric reactions, which serve to distinguish muscles paralyzed by anterior horn or nerve-trunk lesions. If nerves and muscles paralyzed by infantile spinal paralysis are examined five weeks or more after the paralysis has occurred, it will be found that the farado-nervous excitability is very much diminished or, later on, entirely absent. Farado-muscular excitability disappears a little later than that of the nerves. Faradic contractility of muscles is in reality the expression of the faradic contractility of the nerves which ramify throughout the muscle, so that, as soon as the faradic contractility of the nerves is lost, that of the muscles supplied by the nerves is also lost, even if the former are not yet advanced in degenerative changes.

The galvanic current yields even more striking changes. When such a current is passed through a normal nerve the muscles supplied by the nerve will contract. This contraction will be greater at the closing of the negative pole than at the *closing* of the positive; or expressed in formula this reaction will be, K.C.C. > A.C.C.

The *opening* contraction will be A.O.C. > K.O.C.

In a nerve paralyzed by anterior polio-myelitis these reactions will become

$$\text{K.C.C.} < \text{A.C.C., or}$$
$$\text{K.C.C.} = \text{A.C.C.}$$

The opening contraction, if present at all, will also be reversed, A.O.C. < K.O C.

The contraction will also be altered modally; that is to say, while the normal reaction is quick and sharp, the degenerative reaction is slow and wavering. All of these changes are known as qualitative changes; the former serial, the latter modal qualitative changes.

There is, furthermore, a quantitative change. That is to say, while a certain strength of galvanic current may be needed to produce a certain contraction in a normal muscle, a much stronger current will be needed to produce a similar reaction in the degenerated nerve or muscle. What has been said of the galvanic reaction in the nerves applies also to the muscles supplied by them.

These qualitative and quantitative galvanic changes, together with the diminution or absence of faradic contractility, make up what is known as the reaction of degeneration, and it is a most valuable diagnostic agent for the recognition of muscles affected by infantile spinal paralysis.

Differential Diagnosis.—This disease is so frequent in infancy, and has been so well studied in the past few years that, in any given case of paralysis in children, the physician, as a rule, thinks of polio-myelitis as a possible condition. It is fortunate that we have in the symptomatology of this disease much that is positive and characteristic, so that it is possible to arrive at a positive diagnosis in almost every case.

We have to distinguish this affection in children from (1) other forms of paralysis, whether cerebral, spinal, or peripheral in their pathology; (2) paralysis following acute disease, such as diphtheria, meningitis (cerebro-spinal), etc.; (3) paralysis due to toxic action of poisons, such as arsenic; (4) pseudo-paralysis of rickets and marasmus; (5) deformities of congenital origin, such as club-foot and congenital dislocation of the hip; (6) atrophy and disability due to inflammatory joint-disease.

Patients paralyzed from cerebral lesions present the following points of difference from those suffering from this disease: First, the history of the onset of the paralysis is different. It is that of apoplexy or of embolism occurring rapidly, accompanied by repeated convulsions, and, above all, there is the fact that the face and tongue, as well as the limbs, are affected. On examination we find a paralysis corresponding to this history; we may

have (with right-sided paralysis) aphasia in older children. There is frequently loss or diminution of sensibility, the tendon reflexes are exaggerated, while in anterior myelitis these are either absent or diminished in the tendons of the paralyzed muscles and clonus may be present. Even if the muscles of the face have recovered, these symptoms will still distinguish cerebral from spinal paralysis. Furthermore, the limbs are well nourished and not atrophied, the surface temperature is not diminished, and the contractures, if existing, are spastic in variety and present in limbs which have not lost contour through atrophy. What is most important, however, are the results obtained from an electrical examination. In these cerebral cases faradism gives good reactions in the paralyzed muscles, while galvanism gives equally good reactions, the formulas being unchanged either in quantity or quality. On the other hand, in cases of poliomyelitis anterior, we have loss of faradic contractility, while galvanism shows the reaction of degeneration in the paralyzed muscles. The electric examination, together with the history, should certainly yield sufficient data for a positive diagnosis. It is furthermore found that children paralyzed from brain lesions are apt to show a diminution of mental power, which is never present in the patient suffering from poliomyelitis.

Diseases of the spinal cord resulting in paralysis affect directly or indirectly either the anterior gray horns, together with other portions of the cord, or do not affect these horns at all, as, for instance, in secondary sclerosis of the lateral columns. Of the first class we have transverse myelitis, compression-myelitis of Pott's disease, and most probably progressive muscular atrophy, and pseudo-hypertrophic paralysis. Here also belong cases of hæmorrhage into the spinal cord. Here electric examination, although of some, is not of so great utility as in the differentiation from cerebral paralysis. In transverse myelitis we have a paralysis of sensation as well as of motion. There is paralysis of the sphincters, there is the appearance of bed-sores, while the history shows no regression of the paralysis, and the presence of long-continued fever. In the myelitis, or rather meningitis with myelitis as a secondary affection, of Pott's disease, the anterior horns of gray matter may or may not be involved, giving rise to various forms of paralysis. When the anterior horns are involved we shall have paralysis (paralplegia) it is true, but we shall also have the symptoms of vertebral caries, reflexes not abolished, but often increased, and paralysis of the bladder. Faradic contractility is generally preserved, although when the affection of the cord is very extensive it may gradually disappear. Progressive muscular atrophy is not frequent in children, and when it does occur the gradual and progressive nature of the paralysis serves to distinguish it from poliomyelitis. There is also a peculiar "cut out appearance" characteristic of the atrophied muscles in progressive muscular atrophy, the atrophied portions being at first isolated and sharply bounded by well-developed muscles. In pseudo-hypertrophy of the muscles the gradual hypertrophy which accompanies the paralysis is sufficient to distinguish this disease. In the last stages of atrophy in cases of infantile paralysis, as we have already stated, there may be a deposit of fat in the atrophied muscles, but this occurs so rarely, and so long after the paralysis has set in, that the history also will be a certain guide. Hæmorrhage into the anterior horns of the spinal cord, when affecting these portions of the cord alone, can, with difficulty, be differentiated; when it affects other portions of the cord the corresponding symptom will be sufficient to localize the lesion.

Of diseases of the spinal cord which do not affect the anterior gray horns, the most commonly met with in children is spastic paralysis (Erb) or tetanoid pseudo-paralysis (Seguin). These cases were formerly classed with those of infantile spinal paralysis, although the two diseases have scarcely a symptom in common. What has already been said of the differential diagnosis from cerebral paralysis will also apply here, the cord lesion in both cases being a sclerosis of the crossed pyramidal tracts. We have then, here, the absence of the degeneration reaction to both currents, the increased reflexes, the spastic contractures, the absence of atrophy, and sometimes diminished intelligence.

In cases of peripheral paralysis the physical symptoms, those obtained both by the electric currents and by examination, are exactly similar to those present in infantile spinal paralysis. The only important point of difference is that sensation, as well as motion, is apt to be involved in the paralysis of the affected nerve. When the patient is too young for satisfactory tests of sensation to be made, the diagnosis is extremely difficult.

In diphtheria we have the history of the disease (if the diphtheria has not escaped the attention of the patient's friends), the involvement of the muscles of the palate and throat generally, and finally the rapid recovery. We may also have ataxia and paralysis of the eye muscles. The faradic contractility is preserved.

From the paralysis of cerebro-spinal meningitis, the history and what has already been said of cerebral and spinal paralysis will serve to make the diagnosis.

Arsenic and other metallic poisons as a cause of paralysis in children must be extremely rare. I have never seen a case. E. C. Seguin has described several cases in adults in which paralysis resulted from acute arsenical poisoning, and which simulated anterior myelitis.

Cases in which rickets or marasmus have so disabled the lower extremities as to interfere with their use in locomotion are easily distinguished by the fact that there is no true paralysis; these muscles can be used, but walking is impossible, owing to tenderness and softness of the bones in the rachitic patients, and the weakness of the muscles of patients suffering from marasmus.

Congenital club-foot can be distinguished from paralytic cases by the absence of the characteristic electric reaction, and of other symptoms of infantile spinal paralysis.

The disability produced by congenital dislocation of the hips may be mistaken for paralysis, but a careful examination of the hip joints, together with the peculiar gait and the absence of all the symptoms of this disease (infantile spinal paralysis), will serve as aids in making a diagnosis. Finally, inflammatory disease of the joints, especially of the hip, may give rise to atrophy and disability which might cause a suspicion of the presence of infantile paralysis. When the history of joint-disease is taken into consideration, together with the pain and swelling accompanying this condition, it will be hardly possible to be in error for any long period.

Treatment.—Inasmuch as there are no characteristic and pathognomonic signs by which a diagnosis can be made in the inceptive stage of the disease, before the paralysis has occurred, our treatment is necessarily one of symptoms and not rational. We treat, in other words, the fever, the convulsions and the general conditions that may be present. But as soon as the disease itself can be diagnosticated by the presence of paralysis of motion in one or more members, the loss of reflex action, and the retention of sensibility in the paralyzed muscles, then a rational treatment can be instituted. We can attempt a derivative action to the skin by counter-irritation applied either locally to the spinal column, or to the whole of the cutaneous surface. As local counter irritants in robust subjects, cupping and other forms of local blood-letting have been tried. Iodine may be painted along the whole length of the spinal column, or fly-blisters may be applied over the portion of the cord where the lesion is supposed to be located. General derivation to the skin may be accomplished by a strong mustard bath, repeated frequently in the course of a day. These baths, by reducing temperature, will serve to render the patient more comfortable, and will also exert a beneficial action upon the central disease. A brisk purgative may aid in reducing the congestion of the cord, and under any circumstances will benefit the general condition of the patient. Ice applications to the spine are indicated in cases in which the fever is an important factor in the treatment of the patient. The drugs which may be use-

ful in this stage are those which antagonize the febrile movement, and those which are commonly termed as antispasmodic. Of the former class are antifebrin and antipyrin, in doses sufficient to reduce temperature; among the latter are the bromides and chloral, which, together with the antipyretics, will generally succeed in stopping the convulsions. Ergot has been especially recommended by Althaus. He uses Bonjean's ergotine in watery solution (Julius Althaus: "On Infantile Paralysis," London, 1878, p. 51). The dose varies according to age—under five years, from 0.01 to 0.02 Gm. is injected once or twice a day. The treatment is continued until the temperature has become normal.

During the paralytic stage of the affection, the treatment is well understood. Here the indications are, first, to treat the myelitis and thus promote and aid the regression of the paralysis; second, to treat the paralysis.

For the inflammation in the cord we can do but little. Ergot is given with supposed benefit. But the natural course of the inflammatory process is to destroy the ganglion-cells in the gray anterior horns; when this has taken place, it is difficult to conceive how any internal medication can restore the destroyed nerve-elements. It is claimed, however, and perhaps with some propriety, that those portions of gray matter which are only the seat of congestion can be benefited by internal medication; hence the ergot. With the same object in view counter-irritants to the spine are also used, such as iodine painted externally, blisters, and cupping, either wet or dry. Dry cups applied to the spine on a level with the supposed lesion are better than wet cups. For obvious reasons they are also better than blisters.

Electricity is the curative agent in this affection. It may be applied locally to the spine, and also to the paralyzed muscles. Both galvanism and faradism are recommended. In my opinion, however, galvanism is more rational in theory, and more effective in practice. Central galvanization of the spine is performed by placing one large flat electrode over the site of the lesion and the other over the further extremity of the spinal column. An ascending (irritating) current should be employed, of strength sufficient to be felt by the patient; generally from twelve to sixteen elements Leclanché are sufficient. The duration of the applications should not exceed five minutes, and they should be repeated once every second day.

The application of electricity locally to the paralyzed muscles is the most effective use of this agent in this disease. Under the head of deformities we have already discussed its importance as a diagnostic agent. By the use of faradism alone we can recognize whether a patient has been the subject of a spinal-cord or peripheral-nerve lesion, or of a cerebral lesion. In advanced cases of atrophy from this disease the reaction to faradism is entirely destroyed; in these cases, therefore, the application of faradism as a therapeutic agent is certainly useless. I never apply this current until the muscles have sufficiently recovered to show a slight reaction when it is applied. Very few muscles, however—with the exception of those which are entirely destroyed—lose their excitability to galvanism, although the reaction present is generally that of degeneration. Galvanism, therefore, applied to the paralyzed muscles and nerves, causes both to become excited. This stimulus is undoubtedly beneficial, and persevering treatment with galvanism, continued for months and even years, is frequently successful in restoring muscles that were hopeless to all appearances, when the treatment began. I apply the current by the aid of the interrupting electrode to the paralyzed muscles, and the other, generally the cathode, to some indifferent point. Applications to a limb should not exceed three minutes in duration.

Treatment of Deformities.—The principal therapeutic means at our command in the treatment of the deformities are tenotomy and mechanical appliances. Under the latter head I also include massage.

It has long been a question whether it is permissible to cut the tendons of the contractured muscles, and thus virtually paralyze all of the remaining healthy muscles of the limb. But, as is often the case, we find here that what would theoretically appear to be unwarranted, is found, in practice, to be sound and proper treatment. Careful consideration will show that the above objection is only apparently valid. Tenotomy disables a muscle only for a short time. The tendon soon reunites and the muscle is enabled to perform its functions to far better advantage than before. The strained position of the limb is relieved and the patient is enabled to use a joint which was entirely disabled before tenotomy was performed. Conservative surgeons prefer to stretch a contractured tendon, provided it admits of stretching. But such stretching, unless maintained for a very long period, is apt to be of but temporary utility; for a relapse is sure to occur when extension has been remitted. Where time, then, is important, tenotomy is certainly preferable to extension. I do not believe that the argument that tenotomy weakens a muscle is tenable. The active portion of a muscle is certainly not the tendon, but the muscular fibre. Tenotomy results in lengthening the tendon, the muscular fibres retaining their integrity. If healing has been properly looked to, the united tendon will not stretch more than is proper for the restoration of the joint to its proper function. Where, however, the contracture is yielding, traction will readily accomplish all that is necessary, and should be preferred to tenotomy. It will be impossible, in the limits of this article, to describe all of the instruments used for purposes of extension of different muscles. For talipes equinus I know none better than Dr. Shaffer's "extension shoe," the working of which has been thoroughly described in a recent paper read before the Academy of Medicine. For varus, Dr. Shaffer has devised an equally effective "lateral-extension shoe." In calcaneus the chief indication is to raise the heel, the contracture rarely requiring extension or tenotomy. For these cases, as in all cases of paralytic club-foot, the shoe that is worn daily should have inside, covering the sole, a steel plate, to keep the sole firm and to prevent the shoe yielding itself to the deformed position of the foot. If the case be one of equinus, the heel should be fixed to the sole of the shoe by means of a strap passing over the instep. In all cases the shoe should be laced and made so as to open to the toes. The paralyzed muscles in many of these cases can be replaced, to a certain extent, by properly applied elastic straps, to act as artificial muscles. Contracture at the knee-joint should be overcome by tenotomy or extension. If the muscles about the knee-joint do not retain sufficient power to enable the patient to stand or walk with some firmness, we can virtually anchylose this joint by an apparatus in which a rigid bar passes from the hip or thigh down to the foot, without a movable joint at the knee; or a joint may be made at the knee, which, being guarded by an automatic spring, becomes rigid as soon as the patient assumes the standing position. One important principle in the application of apparatus for these deformities must not be lost sight of, and that is, that all apparatus must be so attached to the limb or body that the healthy muscles may be able to control or carry it, while it aids and takes the place of the paralyzed member. On the mechanical treatment of lateral curvature, we will say nothing, the field being too large for the limits of this article. In treating the deformities of the upper arm and hand the principles already laid down will serve as a guide.

Henry W. Berg.

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[13] Hammond: Diseases of the Nervous System.

PARAPHIMOSIS. Paraphimosis is the condition which ensues when a prepuce with a narrow opening is retracted behind the glans and cannot be replaced by the patient himself. The first requisite for the production of a paraphimosis is a certain degree of phimosis, so that paraphimosis may be looked upon as a complication of phimosis. The narrowness of the preputial opening may be congenital, or it may be a temporary condition the result of disease, or a permanent one following cicatricial contraction from former disease. Any condition which causes swelling of either prepuce or glans such as gonorrhœa, venereal ulcers, venereal warts, etc., may be complicated with paraphimosis.

In phimosis the constricted portion which resists retraction is usually the mouth of the prepuce simply. When retracted, the edge of the *ostium preputii* has the same effect upon the parts in front of it as a string or other constricting band. The effect will vary, of course, with the tightness of the constricting ring and the length of time the constriction remains. There may be simply a slight œdematous swelling of the glans, or the strangulation may be sufficient to cause the death of the parts, but it is particularly upon the prepuce itself that the effects of the constriction are manifest. The prepuce swells to many times its normal size and its œdematous tissues become translucent from the contained serum, and when strangulation and necrosis take place, it is the constricting ring of the prepuce that ulcerates and gives way rather than the constricted portion. The appearance of the paraphimosed organ is peculiar and characteristic. The constricting ring is buried beneath a mass of the swollen and œdematous prepuce, which fills the furrow behind the glans and may partially conceal the glans itself.

Paraphimosis is produced by coitus, or by retraction of the prepuce with the hand for any purpose whatever. It happens very frequently, perhaps most frequently, when the parts are swollen from some venereal disease and the patient desires either to learn the condition of the surfaces concealed by the prepuce or to cleanse sores which he knows exist.

The most usual result of an unrelieved paraphimosis is the destruction of the dorsal portion of the *ostium preputii*, forming a demi-circumcision limited to the superior half of the prepuce, but which entirely relieves the constriction. After such sloughing there always remains a sub-preputial tumor on both sides of the frænum, formed by hypertrophy and chronic œdema of the inferior half of the prepuce. Sloughing of the glans and ulceration into the urethra may take place, but they are rare.

TREATMENT.—Of course the indications are to return the prepuce to its original position, and thus relieve the strangulation. The urgency of the operation depends upon the tightness of the constriction. When there is actual strangulation, immediate relief is necessary; when the prepuce is simply so small that the patient himself is unable to slip it forward over the glans, but not small enough to cause anything more than a little swelling of the parts, the call for interference is not so imperative.

The reduction of a simple paraphimosis is usually a very easy matter, if patience and tact are relied upon rather than brute force. The chief obstacle to speedy replacement is the œdema, which very decidedly increases the size of the glans. The first step is the reduction of this œdema, which may be effected by manipulation, carefully compressing the glans between the fingers, pressing the fluid backward until the glans is reduced to small dimensions, when it may be slipped with more or less ease through the prepuce. This is accomplished by grasping the penis with the left hand behind the swollen prepuce while with the thumb and fingers of the right hand the glans is compressed, the index finger on the dorsum depressing the edge of the glans and pressing it back beneath the prepuce, which is pushed forward by the left hand at the same time. Or the penis may be taken between the index and middle fingers of both hands, the organ being grasped immediately behind the swollen prepuce. Then the prepuce being drawn forward by the four fingers, the glans is at the same time compressed by the thumbs and insinuated beneath the preputial ring. Sometimes the handle of a scalpel, a probe, or the blunt end of a hair-pin, may be inserted beneath the prepuce, lifting it over the glans, which is at the same time pushed beneath it and through the constricting ring.

When reduction has taken place there remain puffy swellings on each side of the frænum, which sometimes make one doubt for a moment if reduction has been complete.

When the paraphimosis is recent, and not complicated by disease of any sort, reduction is an easy and satisfactory operation, though somewhat painful to the patient. When the paraphimosis has lasted long enough to set up suppuration and is due to a gonorrhœa or other venereal disease, it is an exceedingly unpleasant thing to handle. In this latter case the penis may be carefully bandaged with a piece of tape, or a narrow bandage, applied so as to press back the fluid from the distal extremity toward the pubes. After a few moments a second bandage may be applied over the first. After perhaps half an hour the œdema will be found greatly reduced, and less handling will be necessary than if the bandage is not used.

The swollen prepuce is often submitted to numerous punctures with a needle, to allow the escape of the serum from the œdematous tissues. This is a pefectly proper procedure and rapidly reduces the swelling, but during the subsequent manipulations more serum is poured out at each pressure of the fingers, and the operation is thereby rendered much more unpleasant to the surgeon than when the surface is dry.

The application of oil is sometimes advised. If it is used at all, it is most appropriately applied only to the portion where the friction is greatest, just beneath the constricting ring. In order to expose the constricting portion of the prepuce it is necessary to draw the skin of the penis a little toward the pubes, when the constriction will be found deeply buried in the œdematous tissues behind the glans. A minute quantity of oil may be applied beneath this ring, but it is unnecessary, and is so likely to smear the whole surface and interfere with the operator's grip that its use is seldom desirable.

When reduction is difficult or impossible, it may be necessary to divide the constricting ring. A director may be slipped beneath the constriction, the overlying œdematous portions being retracted for the purpose, and an incision made by a bistoury.

When the constriction is slight the penis may be bandaged by a narrow roller, as previously mentioned, or by strips of sticking-plaster, and left for twenty-four hours. Of course, in such a case the meatus must not be covered.

Gonorrhœa, primary syphilitic ulcers, balanitis, and mucous patches do not contraindicate either reduction or operations with a cutting instrument. When paraphimosis is complicated with auto-inoculable chancres, however, a cutting operation should be avoided. All sores should be carefully cleansed before covering them with the replaced prepuce.

When a partial circumcision has been performed by ulceration, it will be advisable at some time to complete the circumcision by removing the redundant inferior portion of the prepuce.

Abner Post.

PARAPLEGIA. The term paraplegia specifies a symptom, not a disease. It indicates, in the first place, an impairment of motility, namely, akenesis or paralysis, and secondly, paralysis of a certain distribution. Thus, it is customary to indicate a paralysis involving one of the extremities by the term *monoplegia*, a paralysis of both extremities on one side of the body, that is to say, of longitudinal or unilateral distribution, by the term *hemiplegia*, while a transverse distribution or symmetrically bilateral paralysis of the body is classified as a *paraplegia* (para, Gr. παρα, side by side). Usually, the lower extremities and the caudal portion of the body are the parts involved. The term is not restricted, however, to paralysis of these parts alone, but may be applied to the involvement of any transverse section of the body. When the upper extremities are involved, the term *cervical paraplegia* is applied. In this condition, usually, though not always, paralysis extends to all parts below—caudad. The term *hemi-paraplegia* refers to paralysis of one lower extremity, accompanied by anæsthesia of the opposite member. It is, strictly speaking, a crural monoplegia. The term double hemiplegia is synonymous with cerebral paraplegia, both indicating a paraplegia of intracranial origin, involving the cerebral motor tracts. The term ocular paraplegia has been used, rarely, to indicate paralysis in both eyes, of symmetrical ocular muscles. The term diplegia is to be preferred in cases where a single pair of nerves on each side is paralyzed; as facial diplegia, instead of facial paraplegia. Jaccoud introduced the adjective *paraplegiform* to indicate bilateral disturbances of motility other than true paresis or paralysis, but which resemble the latter in disturbance of locomotion; as that produced by inco-ordination, and spastic conditions.

In paraplegia (it being defined as paralysis of a certain distribution) we have an important symptom of various pathological conditions, forming by its association with other symptoms some of the most striking clinical pictures of disease. Its proper study involves the consideration of the localization of function, the impairment of which produces paraplegia; the nature of the pathological process causing such impairment; the variations in disturbance of function due to involvement of different segments of the body; the other symptoms which may accompany it; and the diagnostic and prognostic significance of the grouping of such symptoms, together with indications for remedial measures.

From this standpoint it forms a convenient centre from which may be analyzed a great number of diseases of the nervous system, mostly of spinal origin, but also including some cerebral and peripheral nervous affections. As we have a motor impairment to consider, the motor tracts of the nervous system must be called to mind. From their periphery in the motor end plates they pass through the mixed peripheral nerves, the anterior roots of the spinal cord, the root zones in the anterior columns, to the anterior cornua of the cord, where the motor nerve-fibres are supposed to terminate in cells arranged in groups or scattered through the gray matter of this portion, and by means of which they form reflex connections with sensory nerve-tracts, commissural connections with the motor tracts of the opposite half of the cord, and with different levels of the cord above and below; and, in addition, connection with the motor tracts in the lateral columns of the cord known as the crossed pyramidal, cerebral, or voluntary tracts, and the direct pyramidal tracts in the anterior columns. After decussation of the crossed pyramidal tracts in the medulla, both crossed and direct tracts pass through the anterior (ventral) portion of the pons, continue through the crura cerebri, then upward, forming a part of the internal capsule, and on to the so-called cortical motor areas. Associated tracts through the cerebellum, the cerebral ganglia, and the nuclei of the cranial motor nerves complete the system. In order to produce paraplegia, not only must some part of this motor system be affected, but the lesion must be symmetrically bilateral, must involve both halves of this duplex system. The general division may be made, therefore, into peripheral, spinal, and intracranial (cerebral) paraplegia. The divergence of the right and left motor tracts in their peripheral and cerebral portions, and their approximation in the spinal cord, medulla, and pons, admit of their frequent bilateral involvement from lesions in the latter regions, and but rarely in the first-named divisions. Consequently, the lesion producing paraplegia is usually a spinal cord lesion. Yet it is possible to have a tumor develop in the longitudinal fissure between the hemispheres, which will involve the motor areas for the legs in each hemisphere, thereby producing a symmetrical and bilateral paralysis of the lower extremities, namely, a cerebral paraplegia. On the other hand, it is now well known that a peripheral paraplegia may be produced by a multiple neuritis involving the peripheral nerves of both lower extremities in such a symmetrical manner as to closely resemble spinal cord lesions. Compression within the spinal cord of the bundle of peripheral nerves known as the cauda equina may also give rise to paraplegia. In the latter case, and also in multiple neuritis, we have the phenomena which attend irritation or destruction of a mixed nerve, namely, motor, sensory, and trophic disturbances in the parts supplied by the nerves involved. But motor, sensory, and trophic disturbance may also occur when the lesion is in the spinal cord, provided it be extensive enough to involve both motor and sensory tracts, and at a level from which the upper or lower extremities receive their motor innervation, namely, the anterior cornua in the cervical and lumbar enlargements. Lesions between these enlargements, or above the former or below the latter, do not produce the trophic disturbances resulting in degeneration of peripheral motor nerves of the extremities, and the consequent atrophy of the muscles which they supply; although voluntary power and sensation may be lost through interruption of the cerebral motor and sensory conducting tracts traversing the section of the cord involved by disease.

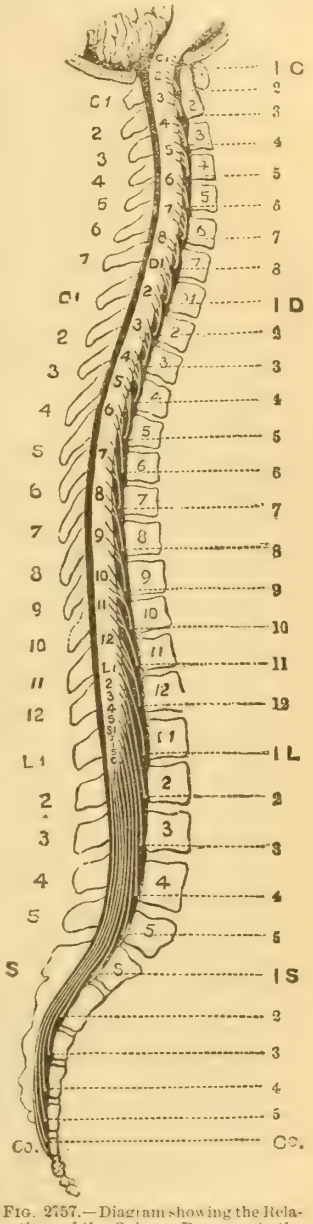

FIG. 2757.—Diagram showing the Relations of the Spinous Processes to the Bodies of the Vertebræ, and of these to the Points of Origin of the Spinal Nerves. (From Gowers.)

Myelitis affecting the entire transverse area of the cord, but limited in its longitudinal extent to some portion between the cervical and lumbar enlargements, commonly known as transverse dorsal myelitis, furnishes an example of this form; while involvement of the lumbar enlargement will serve as a type in which motor degeneration and atrophy are added. Similar results may follow a meningitis, or meningo-myelitis involving the

sensory and motor nerve roots or root zones at the level of the lumbar enlargement. Paraplegia, unaccompanied by loss of sensation may be conceived of in case the meningitic or myelitic process remains limited to the anterior periphery of the cord or to the anterior horns of the lumbar enlargement, by which the motor tract would be involved and the sensory tracts escape implication.

A similar process affecting the cord at its cervical enlargement alone might produce bilateral paralysis of the upper extremities without involving the lower extremities, as long as the myelitic process did not extend deeply enough to invade the pyramidal tracts in the lateral columns. Should it so extend, however, the lower extremities would exhibit paraplegia without loss of sensation and without muscular atrophy; while with a complete transverse lesion at the cervical enlargement loss of sensation in all parts below the upper extremities would be added, but still without degenerative atrophy in the lower part. The meningitic process might be extensive enough to involve both cervical and lumbar enlargements, affecting chiefly the anterior periphery of the cord, producing a paraplegia involving both upper and lower extremities with muscular atrophy in both, and even a transitory loss of sensation; or the gray matter of the anterior horns may be involved throughout the cord on both sides, as in polio-myelitis anterior, with similar results. Finally, we may have involvement of the cerebral (pyramidal) motor tracts in the lateral columns of the cord at any height, cutting off voluntary innervation to all parts supplied below the lesion, but without producing trophic disturbance.

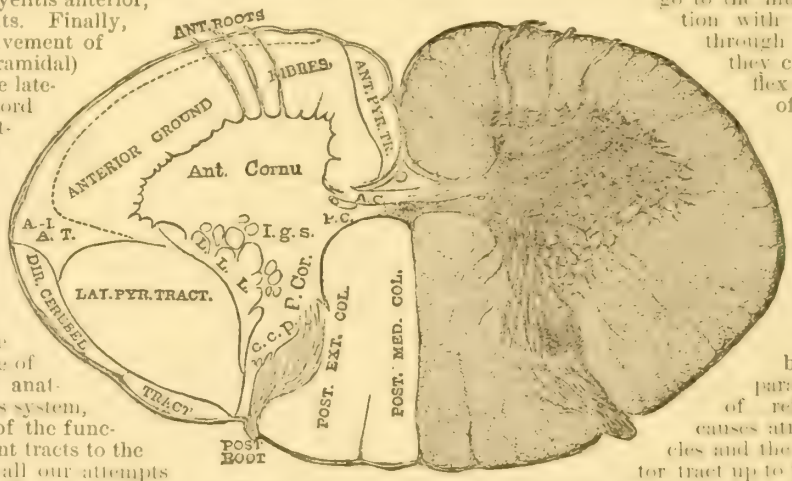

Fig. 2758.—Diagram of a Section of the Spinal Cord in the Cervical Region. A.C., Anterior commissure; P.C., posterior commissure; I.g.s., intermediate gray substance; P.cor., posterior cornu; c.c.d., caput cornu posteriores; L.L., lateral limiting layer; A.L.A.T., antero-lateral ascending tract, which extends along the periphery of the cord. (From Gowers.)

These examples show the necessity of keeping before us a mental picture of the topographical anatomy of the nervous system, and a recollection of the functions of the different tracts to the extent known, in all our attempts to localize a lesion from the symptoms found. The disturbances which accompany the bilateral paralysis constituting paraplegia will vary (1) *according to the level of the lesion* through interference with the visceral, vaso-motor, sensory, and reflex functions of the segment involved; (2) *according to the extent of the lesion transversely in the cord*, through involvement of different functional tracts and centres; and (3) *according to the predominance of an irritative, or of a destructive pathological process* constituting the lesion, producing increase, diminution, or perversion of function. The first and second factors concern the localization of the lesion, the third its nature and course. To aid in the consideration of the former, diagrams and tables are given, and a brief *résumé* of certain anatomical and physiological data.

The spinal canal is longer than the cord, the latter terminating in man at the upper border of the second lumbar vertebra. The exits of the several spinal nerves do not, therefore, correspond to their levels of origin in the cord, nor do the bodies of the vertebræ correspond to their spines. Gowers' diagram (Fig. 2757), showing the relations of the segments, nerves, and bodies of the vertebræ to the spinous processes, together with the table (Fig. 2759) showing the functions of the different segments, are valuable aids to diagnosis. The cervical enlargement corresponds to the lower five cervical spines. The lumbar enlargement to the tenth, eleventh, and twelfth dorsal, and first lumbar, spines.

The ascending tracts of the spinal cord are (1) the antero-lateral ascending tract of Gowers, supposed by him to conduct painful sensations; (2) the direct cerebellar tract, whose function is unknown; and (3) the posterior columns, which conduct tactile and muscular sensations. Fibres serving the latter function, it is thought, occupy part of the median division of the posterior columns (columns of Goll), and do not decussate, while other sensory fibres do. The external columns (columns of Burdach) include the posterior root zones and fibres having a short course up and down the cord, probably decussating at higher levels, or connecting different levels of the cord. The ascending tracts degenerate upward from the level of a destructive lesion. The descending tracts are the direct and crossed pyramidal tracts, concerned in the transmission of cerebral impressions downward to the motor centres in the anterior horns. They diminish in size downward, going chiefly to the cervical and lumbar enlargement; the direct tract mostly to the former. The remaining parts of the anterior column and the lateral limiting tract are supposed to contain commissural conductors of motor impulses between different levels of the cord on the same side. The anterior roots originate in the gray matter of the anterior cornua as already described, traverse the anterior columns (anterior root-zones), and go to the muscles. In connection with the sensory roots through the gray matter, they constitute the "reflex arcs," interruption of either the motor or sensory division of which abolishes reflex action in that segment. Destruction of any portion of the motor division from the muscles to the cells of the anterior cornua, including the latter besides producing paralysis and abolition of reflex action, also causes atrophy in the muscles and the corresponding motor tract up to the point of lesion, which is characterized by the electrical reaction of degeneration. This does not follow a lesion of any other part. Destruction of the pyramidal tracts causes a degeneration of the column downward from the point of lesion, but this does not usually go beyond the connections of these tracts with the cells of the anterior horns. Atrophy, and the reaction of degeneration are absent. The reflex arc is not only preserved, but reflex excitability is increased. Impairment of voluntary power and exaggerated motor reflexes frequently amounting to clonic or tonic spasm, characterize lesions of these tracts. Lesions of the cervical region may be accompanied by disturbances of respiration, of the cardiac functions, of the cilio-spinal centre (radiating fibres of iris), and by vaso-motor phenomena, showing either increased or diminished functional activity, as the lesion is irritative or destructive. Lesions in the lower segments of the cord interfere with certain functions of the bladder, the rectum, the sexual, and the vaso-motor apparatus in a similar manner, serving as aids to localization.

As disturbances of the bladder and rectum are usually important features in the paraplegic state, their complex functions should be referred to. Each of these organs has two sets of muscles, which are opposed to each other in action—the detrusors, which expel the excretions, and the sphincters, which oppose expulsion. Besides the local nervous apparatus found in the walls of all hollow muscular organs, and which probably constitutes a reflex apparatus between the mucous membrane and the sub-

jacent muscular, vascular, and glandular apparatuses, in a manner not fully known, these organs have their opposed muscular movements represented in the cord by motor centres situated somewhere between the origin of the second and fifth sacral nerves, and a reflex arc is established through sensory fibres from their mucous membrane and muscles. In addition to this there are sensory connections (posterior columns) with the brain, and voluntary paths from the brain (pyramidal tracts), by which a certain amount of control is obtained over the sphincters and detrusors, the mechanism of which is but imperfectly understood. The important facts for pathology are that, as in the involvement of other motor organs, lesions above the motor centres in the cord simply cut off the

Table showing the approximate relation to the spinal nerves of the various motor, sensory, and reflex functions of the spinal cord.

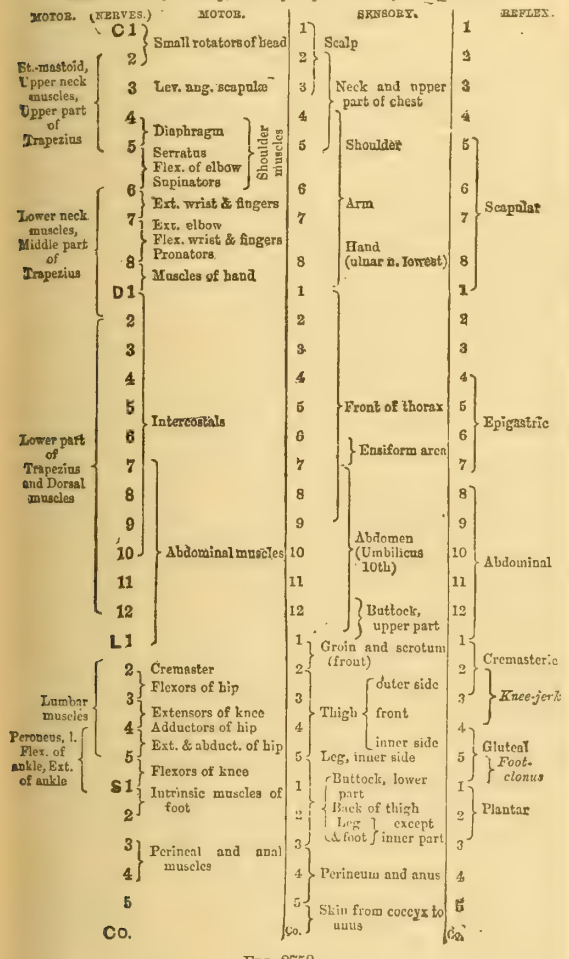

FIG. 2759.

sensory impressions from these organs to the brain when the ascending tracts are destroyed, and interrupt voluntary impressions to them when the pyramidal tracts are destroyed. In the former case, there is no consciousness of the necessity of micturition or evacuation, and therefore no attempt to restrain it. In the latter, there is consciousness of the necessity, but inability to resist the expulsion. When both paths are cut off there is neither desire nor power to expel the excretions—involuntary and unconscious evacuations take place through the reflex mechanism in the cord; but when the lesion destroys the motor-centres of the bladder and rectum, expulsive power and the power of the sphincters are lost, and the retention of excretions results, except evacuation due to the mechanical expulsion of liquid fæces and the dribbling of urine.

In most of the examples given to illustrate the question of localization of the lesion, destructive lesions have been assumed—that is to say, abolition or diminution of function, rather than the intensified activity of an irritative lesion. It should be borne in mind, however, that in most cases, before a pathological process becomes destructive, an irritative stage has existed; and that the irritative and destructive stages may so vary in their course and duration that both processes go on at the same time in different areas involved by the lesion. Thus paralysis may be preceded by clonic or tonic spasm; anæsthesia, by pain and by paræsthesia; abolition of reflex action, by an exaltation of the reflexes; vaso-motor paresis and failure in nutritive processes, by functional exaltation. Or, as instanced in paraplegia from transverse myelitis, between the focus of disease, in which function is lost, and the healthy portion, there is usually a region of increased activity—an irritated zone. The balance between these opposite conditions, which shade into each other, and the degree and extent of each, will vary with the nature and rapidity of the pathological process producing it.

Concerning the nature of the pathological process, the common division into structural and functional will serve our purpose; meaning by the latter, that in which no perceptible structural change exists—abnormal variations in those molecular movements which constitute functional activity, and which are, therefore, dynamic rather than static in character. This class comprises many of the defects due to unstable molecular conditions, partly inherited partly acquired, and frequently dependent upon imperfect nutritive processes in the neural tissues, either assimilative or excretory. From this extreme, we have a gradation into coarser forms of molecular derangement, and, finally, into those in which the microscope, or the eye alone, distinguishes derangement in structure. Taking the latter first, as being more tangible, we find that nearly all structural neural disease begins in non-neural tissues. True, we may have direct traumatisms, as cutting, crushing, and compression of neural tissues; and there may be degenerative processes originating primarily in nerve-fibres and -cells, and direct toxic effects from organic or inorganic poisons conveyed by the nutrient fluids; but there is a larger group of disorders which are secondary to inflammation, acute or chronic, in the connective-tissue structure which forms the frame-work or support of the neural elements, or to vascular disease, such as hæmorrhages, thrombosis, embolism, or proliferative occlusion.

Leaving the consideration of these elementary propositions, we pass on to consider the actual clinical forms of disease which result in producing paraplegia.

Taking the disease which most frequently produces paraplegia, myelitis, as a type, let us study its most common form—namely, transverse dorsal myelitis. This name implies that the entire transverse area of the section is more or less involved in the inflammatory process, and does not include the more limited centres of myelitis, termed *focal* lesions, which may be located in one-half of the cord, and rarely produce paraplegia; though this may result when independent foci involve motor-tracts of the anterior horns or root-zones, at the same level, or the pyramidal tracts even at different levels. Where several myelitic foci exist, the term *disseminated focal myelitis* is used. While the term "transverse" implies that the longitudinal extent of the lesion is limited, this is not construed in a narrow sense, and may be properly applied when the lesion invades both the lumbar enlargement and the dorsal segments. When the entire length of the cord is involved, the term *diffuse myelitis* is applied; this may be general—*i.e.*, involving both white and gray matter—or may be limited to the latter, when the term *diffuse polio-myelitis* (myelitis of gray matter) is used. The term polio-myelitis anterior indicates that the anterior cornua alone are invaded; while the term *central myelitis*, or *diffuse central myelitis* (according as it is local, or general), is applied to polio-myelitis originating about the central canal and invading any portion of the remaining gray matter. Other adjectives are in use—such as *hæmorrhagic myelitis*, when secondary to a hæmorrhage within the cord; *compression-*

myelitis, when secondary to compression of the cord, as from tumors, inflammatory exudations, and fractures or dislocations of the vertebræ; *meningo-myelitis*, when the inflammatory process invades the membranes and cord. The terms acute, subacute, and chronic prefixed to these various terms, specify whether the onset has been sudden, gradual, or slow.

1. Acute Transverse Dorsal Myelitis (involvement of any segment of the cord between the cervical and lumbar enlargements).

Symptoms.—Paraplegia resulting from this disease is usually characterized by the rapid onset of motor weakness of the lower extremities, preceded by numbness and painful tingling in the extremities; formication and other paræsthesiæ, moderate or severe; pain in the back and limbs, of a boring, tearing character; irregular twitching of muscular fasciculi; painful tonic spasm (cramps), and tremor of some of the muscles of the extremities; besides, in many cases, general febrile symptoms, usually of a moderate grade, and in rare cases eclampsia, particularly in young subjects. The motor weakness may be hours or days in reaching its highest degree, and this may be gradual, or by a succession of sudden accessions with intervals of partial recovery. Before it becomes complete the gait is similar to that of double hemiplegia of cerebral origin, for it is due to involvement of the pyramidal tracts. The superficial (skin) and deep (tendon) reflexes of the extremities are preserved, and the paralyzed muscles respond to such reflex excitation and also to electrical stimulation; the reaction of degeneration is absent, and the muscles of the extremities do not undergo atrophy except from disuse. Later, the reflexes become increased, often to a high degree. Spastic conditions and contractures may follow, and frequently become permanent. The lower trunk-muscles may be involved and flaccid, showing diminished response to faradic excitation; there is retention of urine at first, followed by incontinence from reflex action. The sphincter ani is also cut off from cerebral control.

The pulse is usually rapid. Sensation is rapidly lost; anæsthesia takes the place of the painful paræsthesia, though frequently a condition of hyperæsthesia exists, particularly in the distribution of the nerve coming from the limit of the lesion, where it may form a zone producing the sensation of constriction about the trunk. The dorsal spines may also be sensitive to pressure at this level, but the pain and hyperæsthesia are not increased by active or passive movement. All sensation in the parts supplied from below the upper margin of the lesion may be cut off. If recovery takes place, sensation is usually regained before motion. Death may result from general exhaustion, though myelitis limited to the dorsal region is the most favorable form for recovery. If it extends to the cervical region, respiratory failure may follow; or if it invades the lumbar enlargement, bed-sores, cystitis, and nephritis may hasten death. The course and duration, as well the acuteness of onset, are very variable. Months may elapse before recovery takes place; or sensation may be partially recovered, and there may be some return of power, but with spastic conditions which may persist for years. But some cases recover so completely and rapidly that after a few months no trace remains, except an increased patellar tendon reflex.

When the myelitic process involves the lumbar enlargement, either primarily or by the extension from the dorsal region, we have

2. Acute Transverse Dorso-Lumbar Myelitis. Here additional phenomena are present, due to the destruction of the motor and reflex connections for the muscles of the lower extremities, and for the bladder, rectum, and sexual apparatus. In place of increased reflexes we have both skin and tendon reflexes abolished. The reflex functions of the bladder and rectum are lost, as already described. Alkalinity of the urine, cystitis, and suppurative nephritis may follow. The muscles of the extremities are flaccid, undergo atrophy, and after a time the reaction of degeneration is found (frequently not before a week or two after paralysis).

Trophic disturbances in the skin and subcutaneous tissues, in the form of bed sores, frequently occur over the sacrum and the buttocks, and sometimes suppuration in the pelvic cellular tissue. The skin of the extremities is often œdematous, livid, and, in late stages, subnormal in temperature, although at the onset it may be supernormal; it may be dry or moist.

3. Acute Transverse Cervical Myelitis. In this form the lower extremities and pelvic viscera are affected as in the dorsal variety, and in addition, changes occur in the upper extremities similar to those described in the dorso-lumbar variety for the lower extremities—namely, trophic changes in the muscles and nerves, and in the electrical reaction and the reflexes; besides, vaso-motor, pupillary, cardiac, and respiratory disturbances occur; painful rigidity of the cervical muscles, pallor or flushing of the face and neck, contraction or dilatation of the pupils, and slowness or rapidity of the pulse, according to whether the irritative or destructive stage prevails. Optic neuritis has been found associated. Priapism is a more frequent condition in this than in the dorso-lumbar variety. The upper extremities are paralyzed first. If the process remains strictly a central myelitis, the lateral column will not be invaded and the lower extremities will not be involved. Should the section involved lie above the cervical enlargement, the upper extremities would be affected like the lower ones—namely, preserved and exalted reflexes, and absence of trophic changes in the muscles. Respiration, deglutition, articulation, and the diaphragmatic functions (origin of phrenic nerve) may exhibit great disturbance, death usually resulting from respiratory failure.

The morbid anatomical changes which constitute the basis of these symptoms are the result of irritative and destructive inflammatory processes in the cord; the irritative stage being represented by hyperæmia, exudation from the vessels, proliferation of lymphoid elements, minute capillary extravasation, and frequently by hæmorrhage from small arteries. Later, the myelin of the medullated fibres undergoes swelling, granular degeneration, and disorganization. The axis-cylinders and nerve-cells may become swollen, opaque, or granular, some undergoing complete disorganization—this representing the stage of destruction. The latter process may continue until complete softening occurs, showing, on section, a softened or liquefied state, and under the microscope, the débris of nerve-cells, broken cell-processes, myelin-drops, lymphoid bodies, red blood-cells, and the so-called granule-cells—bodies many times the size of lymphoid elements, filled with highly refractive granules. When the process stops short of complete disorganization and a more chronic stage is reached, and also in the earlier stages of chronic myelitis, the neuroglia proliferates, forming more numerous and thicker bands; the walls of the vessels are thickened; lymph-spaces may be obliterated or choked with lymphoid cells; so-called spider-cells (Deiter's cells), larger connective-tissue cells, with larger and numerous processes, are scattered through the tissues, and the so-called corpora amylacia are numerous.

This condition is known as sclerosis. It presents a grayer appearance in unstained sections; deeper red with carmine, and a paler color with the Weigert process, than the normal tissue. The naked-eye appearance, where the cord has undergone softening, has been divided into red, yellow, and white softening, representing successive stages during which the extravasated red blood-cells are being absorbed. The more vascular parts of the cord are usually the first to undergo softening. These are on either side of the central canal in the gray matter, the process usually extending outward to the white columns, frequently along blood-vessels or connective-tissue trabeculæ. The appearances of softening or sclerosis on section are often quite irregular, particularly in the white matter.

Simple Softening of the Cord is met with, probably due to occlusion of the vessels from arteritis, embolism, or thrombosis. There are fewer signs of an active inflammatory process, white or yellow softening being found. It is characterized by the absence of marked irritative symptoms, which precede the destructive stage of the inflammatory variety.

Hæmorrhagic Myelitis is characterized by a more sudden onset of the paraplegia than occurs in the inflammatory form, frequently becoming complete in a few minutes. The occurrence of traumatic conditions, as concussion, injuries to the vertebræ, etc., will frequently lend support to this diagnosis. The later changes are similar to the forms already described. A hæmorrhage may be so small and so located as to produce only unilateral paralysis at first, as in the anterior cornua, paraplegia recurring later from a more general myelitis, secondary to the hæmorrhage.

Compression-Myelitis presents the usual features of a transverse myelitis, except that paraplegia may be preceded for a longer time by irritative symptoms than in the common inflammatory form, as compression is usually slow, being due to tumors in the membranes, or to vertebral disease. In its common form it is known as *the paraplegia of Pott's disease.* The paraplegic symptoms are those due to irritation of the sensory and motor nerves at their exit from the membranes, which may present pachymeningitis, or from the vertebral foramina, giving rise, chiefly, to bilateral pains in the trunk or upper extremities, in the course of the sensory nerves involved, frequently accompanied by hyperæsthetic or anæsthetic areas. Herpes zoster sometimes occurs. The reflexes and the functions of the sympathetic may be disturbed (pupillary, vaso-motor, sweating), and even muscular paresis and atrophy of the upper extremities follow, from this cause. The chief diagnostic features are evidence of localized bone disease, curvature, spinal tenderness on movement, and reflex muscular spasm at the region involved on flexure of the spinal column. Paraplegia, when it does develop, may appear suddenly. The distribution of the paralysis is usually that of the dorsal or cervical varieties, and presents the variations in localization of lesion described for these conditions.

It is considered one of the most favorable forms of myelitis respecting partial recovery.

In Compression by Tumors pain is such a prominent feature that Cruveilhier was led to characterize the paralysis it produces as *paraplegia dolorosa.* The pain is lancinating, at first intermittent, but finally becoming constant, and increased by movement. It is of a more severe character than the pain of vertebral caries. All varieties of localization may be presented, and all possible variations in mode of onset, and in slowness or rapidity of course, depending on the location, size, and rapidity of growth of the neoplasm, various symptoms becoming prominent according as different functional tracts are chiefly involved. Sarcomata (including gliomata) are the most frequent; gummata and tubercle are about equally common, while carcinomata and hydatids are among the neoplasms occasionally found.

Meningio-Myelitis may result from an extension of the myelitic process outward to the membranes, or of a meningitic process into the cord.

Meningitis, both acute and chronic, may produce paraplegia by involving the anterior roots. When the entire circumference of the cord is involved, the sensory roots being also affected, we have a similar condition to involvement of a mixed peripheral nerve.

The lancinating pains, constrictive bands, muscular rigidity, and convulsive twitching are greater than in simple myelitis, and usually serve to distinguish one from the other. In cervical meningitis the paraplegia will be confined to the upper extremities, as the pyramidal tracts will be free unless there develop a meningio-myelitis, when these tracts may be involved.

As numerous examples have already been given, it will be unnecessary to review all the possibilities that may follow, or to consider all the varieties of meningitis. With a clear appreciation of the anatomical relations and functions, the extent and location of the lesion may be concluded from the symptoms, or vice versa. *Traumatisms* may also be left out of consideration, after what has been said on compression-myelitis.

Polio-Myelitis Anterior (infantile and adult spinal paralysis) may produce a paraplegia; usually, however, the lesion in this case being limited to the anterior cornua and its neighborhood in the anterior columns, certain cell-groups succumb, while others survive, leaving an irregular distribution, not symmetrically bilateral, and therefore not paraplegic. The anterior group of one leg is most frequently involved. Nearly one-half the cases are monoplegic, and when bilateral, the paralysis is frequently not symmetrical. It should be stated, however, that often during the first hours, and sometimes days, of this sudden paralysis, there is complete paraplegia, the trunk and all four extremities being involved; but it is distinguished from transverse myelitis by the absence of marked sensory or vesical symptoms, and by abolished reflexes. The statement concerning the unsymmetrical distribution of the paralysis also applies to the subacute form of this disease, and, in fact, to chronic degeneration of the anterior cornual cells, which produces progressive muscular atrophy.

The condition known as Landry's acute ascending paralysis, and also the lateral amyotrophic paralysis of Charcot, which may produce paraplegia, are so rare as to warrant no more than their mention.

The paraplegiform affection due to the ataxia of tabes dorsalis may give place to a true paraplegia by an extension of the degenerative process to the anterior cornua, producing muscular atrophy, or in the form combined with sclerosis, by involving the pyramidal tracts, may develop spastic and ataxic paraplegia.

Spastic Paraplegia results, as we have seen, from the symmetrical involvement of the pyramidal tracts in any part of their course, and is usually secondary to a transverse myelitis, or transverse lesion of the pyramidal tracts in their intercranial portion, or, particularly in infants, to arrested development of the cortical motor areas, in both hemispheres. It is sometimes termed double hemiplegia. It may affect chiefly the arms, or the legs, and has the usual characteristics, namely, spastic movements, exaggerated reflexes, and absence of sensory and trophic changes. Primary sclerosis of the pyramidal tracts in the cord is a rare condition, if it occurs at all.

Intracranial tumors, by pressure upon the crura and pyramidal tracts in the pons and medulla, or in the cerebellum, may produce paraplegia or paraplegiform symptoms, in some cases being ataxic rather than paretic, or a combination of both.

Paraplegia from Multiple Neuritis is characterized by both motor and sensory impairment involving all the extremities, and ascending the members from periphery to trunk, also by pain, hyperæsthesia, tenderness of the nerve-trunks to pressure, trophic changes in the muscles, the reaction of degeneration, œdema of the extremities, the absence of visceral disturbances (bladder and rectum), and the absence of a constriction band. It is most common in those addicted to alcohol, but is also a manifestation of certain endemic diseases, such as beri-beri and kakké.

Pseudo-hypertrophic Paralysis produces a form of paraplegia somewhat similar to polio-myelitis anterior, and is considered by some to be a form of that affection, by others to be a connective-tissue disease of the muscles. The increase in size of the muscle (usually the calves) and its hardness, serve to distinguish it from ordinary polio-myelitis anterior.

There are several forms of paraplegia usually classified under functional disorders of the nervous system, namely, hysterical paraplegia, paraplegia depending upon idea, reflex paraplegia, malarial paraplegia, anæmic paraplegia, alcoholic paraplegia, and toxic paraplegia.

Hysterical Paraplegia is a less frequent form of hysterical paralysis than that of hemiplegic or monoplegic distribution. It is less apt to be confounded with paralysis of organic origin than the other varieties, for the reason that hysterical paralysis resembles in its symptoms a lesion of cerebral motor-tracts in the brain and cord, rather than one in the remaining portion of the motor-tract in the cord and peripheral nerves. The reaction of degeneration is absent in hysterical paralysis. Atrophy may be present, but it is that form dependent upon disuse. The volume of the muscles may be reduced in such cases, and give a feeble reaction to electri-

cal excitation; but, what is of the utmost importance, *faradic excitability is preserved and the contractions are good.* The skin and muscles may be cold, livid, and flabby, resembling paralysis from peripheral or cornual disease, and contractures may form as in degeneration of the pyramidal tracts, though in many cases the muscles and skin appear normal, except that voluntary control is lost. The tendon reflexes are rarely lost; usually they are increased, sometimes excessively so. The bladder and rectum are not usually affected, though voluntary control over these organs may be lost. Thus, paraplegia from transverse myelitis of the lumbar enlargement would not be confounded with hysterical paraplegia on account of the absence in the latter of trophic and electrical changes in the muscles and nerves, bed-sores, and atrophic changes in the bladder; but the latter might closely resemble paraplegia from transverse dorsal myelitis in which these signs are absent. The presence of a constriction band at the level of the segment involved, and the sensory, motor, or reflex disturbances in this zone would exclude hysterical paraplegia. Hysterical paralysis of all the extremities might simulate cervical paraplegia of myelitic origin, but would be differentiated from it by the presence of trophic changes in the muscles of the upper extremities, and the vaso-motor and visceral symptoms accompanying organic lesions of this region. Again, the onset and course of the two classes of disease are usually sufficient to distinguish one from the other. The irritative stage of most acute or subacute organic diseases of the cord, in which pain, hyperæsthesia, and slight motor irritation precede the paretic and anæsthetic period, is not usually present in hysterical paraplegia. In the latter, sudden development of the paraplegia, and sudden variations in its distribution and intensity, often serve to indicate it. Anæsthesia and analgesia may have a distribution inconsistent with the lesions producing paraplegia of structural origin.

It must not be forgotten that hysteria may accompany organic lesions, and should not, therefore, be taken as proof of the hysterical nature of the paralysis, unless organic lesions can be excluded.

Paraplegia Dependent upon Idea is a form described by Dr. J. Russell Reynolds. Though closely allied to hysterical paralysis, it may be independent of hysteria, hypochondriasis, and simulation, though frequently associated with functional debility, anxiety, and a morbid imagination. "Many cases of paraplegia following railroad accidents," says Reynolds, "may be classed under this head; the attention of the victim being influenced in the most unfortunate manner by the stories of friends, inquiries of his physician, the talk of his attorney, and the sober face of the company's physician." Pain, distributed in a manner inconsistent with the anatomical relations, on the supposition of an organic lesion; spasm, which, however, is sometimes relaxed in a remarkable way when the patient's attention is directed elsewhere; and paralysis, which is rarely complete, and almost identical with a voluntary attempt not to move the parts, or to move them with care, as in simulation, are the chief features of the affection. The removal of the morbid idea, *i.e.*, that the patient is paralyzed, or has a severe disease, results in improvement or cure. An award for damages has also frequently proven a valuable therapeutic agent in such cases.

Reflex Paraplegia, termed by older writers urinary paraplegia, was shown by Brown-Séquard to follow irritation not only of the genito-urinary tract, but also of the intestines and other viscera in animals. He attributed it to an anæmia of the cord, due to contraction of the blood-vessels, while Charcot considered the motor weakness due to inhibitory action of the sensory irritation. While we must admit the possibility of this form of paraplegia, it should not be forgotten that organic lesions may have been lost sight of, or might be sufficiently slight to be transitory. The positive evidence of some form of peripheral irritation, the removal of which has been followed by recovery, is the only basis on which it should be admitted, and then only in the absence of indications of organic disease.

Malarial or Intermittent Paraplegia is a curious form of polio-myelitis anterior, which recurs with the periodicity of intermittent fever. Alcoholic paraplegia, when not due to multiple neuritis, is a temporary affair, following an alcoholic debauch.

The anæmic form follows ischæmia of the cord, from pressure on the abdominal aorta, and from pressure or occlusion of the iliac arteries within the pelvis, or ischæmia of muscles: rare conditions.

The indications for treatment, where paraplegia exists, are those adapted to the correction of the various pathological processes concerned in the diseases we have considered. More than a brief *résumé* would carry us beyond the proper limits of this work. In the irritative stage of acute meningitic and myelitic processes, rest is the first essential. The reduction of hyperæmia, by means of agents supposed to cause vaso-motor contraction, such as ergot and belladonna, and the relief of pain by means of cutaneous irritation, as the actual cautery, blisters, sinapisms, cupping, etc., and also by morphia, may be attempted. The use of cold to reduce inflammation in spinal-cord disease is an uncertain procedure, concerning the real effects of which we know but little.

In the destructive stage of these conditions, when paralytic and anæsthetic phenomena are present, rest may still be an important factor. The use of mercury, and of potassium iodide, may be of service in this period to promote the absorption of exudations.

In later stages and in chronic cases the use of tonics of iron, strychnia, arsenic, etc., are called for. Nitrate of silver may be indicated. Electricity is usually to be avoided in the irritative stage of an acute affection; or, if used, as for the relief of pain, it should be in the form of a gradually increased galvanic current, avoiding interruption. For the paralysis, the interrupted galvanic and the faradic currents, to produce muscular contractions, and spinal applications of the uninterrupted galvanic current, are of value, as are also massage and passive movements. For anæsthesia, the faradic brush is often serviceable.

Extreme care and cleanliness are essential in all cases of paraplegia, and the avoidance of pressure and irritation over the buttocks and sacrum, on account of the danger and frequency of bed-sores. Attention must be paid to the bladder and rectum. Catheterization, conducted with extreme cleanliness, may be necessary, and also antiseptic irrigation of the bladder. Constipation must be prevented by cathartics, enemas, etc. Compression-myelitis from caries, dislocations, fractures, and other traumatisms requires appropriate surgical treatment.

W. R. Birdsall.

PARASITES are those creatures that depend on some organism for nourishment and lodging. They may be either vegetable or animal (phyto- or zoo-parasites), and may be found upon either vegetables or animals. But, generally, in medical writings, the term is restricted to animal parasites living on or in animals. Many of these parasites occupy this position only during part of their lives.

The proportion of different kinds of animals that are parasites varies greatly. Among the vertebrates there are almost none, while of insects, crustaceans, and especially worms, there are extensive groups which are mostly or entirely parasites.

If the animal only comes on a neighbor for a meal, it is called a "temporary" parasite; if it stays for a lengthy period or a life-time, it is a "stationary" parasite. The former must, of course, be provided with locomotive apparatus for reaching and leaving its host (fleas); for the latter this is unnecessary (tæniæ), but it has, instead, organs to assist in maintaining its place, such as suckers, or hooks.

Perhaps there is no species of free animal that is not occasionally troubled with parasites, which, again, may be infested with their own parasites. No matter how careful the mother may be of her offspring, the evil companion will find it out. Thus the melée, or bee-louse, in larval state will cling to a bee as it gathers honey, and be carried to the hive to be deposited in a cell of honey, which it devours, thriving on the food intended for the young bee.

But while the vertebrates are most liable to parasites, the invertebrates are not exempt; the ichneumon fly in-

troduces her eggs, by means of a long ovipositor, into a healthy caterpillar, where the larvæ are hatched and eat up their host.

We have most interest in the parasites affecting man, of which we know about fifty varieties; next, in those of the domestic animals, which have half as many, or more, with which we are acquainted. Fortunately, these are not all found in one locality.

These parasites infest different parts of the body—skin, intestines, muscles, viscera, brain, and eye may have their special enemies; even the embryo does not always escape. Of course, the parts most frequently infested are those most accessible. More than three-fourths of human parasites are found on the skin or in the intestines. But sometimes a particular parasite is not limited to one organ. The trichina passes from the intestine to the muscles; the echinococcus passes to the liver, spleen, lungs, etc.

Parasites often, perhaps generally, infest one host at one period of life, another at a subsequent stage. A parasite which exists in the larval stage in pork and beef is found as the developed tape-worm in man and in some of the carnivora.

Some parasites occur so rarely in certain animals that their presence is exceptional, while they are common in others. Distoma hepaticum is very frequent in ruminants, but very unusual in man. Strongylus gigas is also very rare in man, but common in beasts of prey.

Some parasites have lungs, and require an opportunity for breathing (as fleas, lice, maggots, etc.), and they must remain on the surface or in such places as are accessible to the air, as in wounds, the meatus of the ear, under the prepuce, etc.

Parasites may be divided into ecto- and ento-parasites (or entozoa), which words explain themselves. The former, living on the surface and often leaving one host for another, have organs of locomotion, or, where these are deficient, they have organs for attaching themselves to their host; of course, the breathing apparatus must correspond with that of the host. Living on the surface, the parasite must have a mouth fitted for eating epidermis (as some lice) or for biting through the skin to reach the blood or other juices (as fleas, mosquitoes, etc.), as well as a suction-apparatus. Of the internal parasites few need such mouths, unless (as Anchylostomum duodenale) they bore into the intestinal walls for blood; they usually take in fluids from the contents of the intestines, and even these are sometimes absorbed through the skin, as is the case in tape-worms.

Entozoa (from *ἐντός*, within, and *ζῷον*, animal) is a name given to animals, chiefly worms, living in man or other animals. They inhabit not only the intestines, but all parts of the body. Those that have been observed are, of the

Nematodes: 1, Filaria medinensis, in the cellular tissue; 2, Filaria bronchialis, in the bronchial glands; 3, Filaria oculi humani and cysticercus, in the crystalline lens; 4, Trichocephalus dispar, in the cæcum; 5, Spiroptera hominis, in the bladder; 6, Strongylus gigas, in the kidneys; 7, Ascaris lumbricoïdes, and 8, Ascaris alata, in the small intestine; 9, Oxyuris vermicularis, in the rectum; 10, Anchylostomum duodenale, small intestine; 11, Trichina spiralis, in the muscles.

Among the *Arachnidæ* are: 12, Pentastoma tænoides and constrictum, in the small intestine and liver, in Egypt.

Trematodes: 13, Tetrastoma renale, kidney; 14, Distoma hepaticum, bile-ducts; 15, Distoma lanceolatum, bile-ducts; 16, Distoma oculi humani, crystalline lens; 17, Distoma heterophyes, small intestine, in Egypt; 18, Distoma hæmatobium, vena porta, Egypt; 19, Polystoma penguicola, ovary (?); 20, Polystoma venarum, tibial vein (?); 21, Monostoma lentis, crystalline lens.

Cestoids: 22, Bothriocephalus latus, and 23, Tænia solium, small intestine; 24, Tænia nana, small intestine and liver, Egypt; 25, Cysticercus cellulosæ, all tissues; 26, Cysticercus visceralis (?); 27, Echinococcus hominis, in the liver and other parts.

If the entozoon enters the firmer tissues of the body it sometimes becomes encysted, the cyst being formed from the connective tissue of the part in which it has located; this cyst, being supplied with blood-vessels, furnishes nourishment to the parasite, which may remain in this condition for years.

For a long time it was supposed that many parasites (worms, larvæ) were developed by spontaneous generation. But when the microscope revealed minute beings in earth and water, where their existence had not been suspected, this doctrine lost ground.

Among other things, the discovery in water of a tape-worm (which infests the stickleback) induced the belief that these beings existed free and were taken in by other animals. Pallas said there could be no doubt that eggs of intestinal worms were sown outside of the body, and there underwent changes, to become worms when again taken into the body with food or drink.

Kuchenmeister, by feeding animals with the segments of tape-worms, discovered the subsequent changes.

The period of sexual maturity and propagation usually occurs during the time of their parasitic life, and where only one sex is found as a parasite, it is the female. The external parasites are born and may grow up in the same place, but the entozoa do not. It has been supposed that the Oxyuris vermicularis was an exception to this rule, and that its eggs were hatched out in the place where they escaped from the mother; but this seems to have been disproved, and it would appear hardly probable that there should be this exception to a general rule.

Generally the eggs of entozoa escape from the intestine and are then swallowed by other animals. Their shells are digested by the new host, and the embryo is freed. So the liability to infection may depend on the digestive power. Eggs of tape-worm will thus be freed by mammals, but not by frogs or other cold-blooded animals whose digestion is feebler. When the young parasite has found its host it loses the organs intended for use outside, such as cilia, fins, eyes, etc.

When the proglottides of tape-worm are dropped with the fæces (of the carnivora) they are full of eggs and active; they may crawl out and attach themselves to grass or shrubs, and then be eaten by the herbivora, and the eggs will then pass through another stage of development, to go again into the carnivora and become tape-worms.

Active parasites may choose proper localities for laying their eggs. Horse-flies, for instance, lay theirs on the hair, where the horse can lick them off and thus carry them to his stomach. The ichneumon fly has an oviposito for introducing its eggs into the body of its victim.

Where there is so-called "chance" about the eggs finding, or being found by, their proper host, the eggs make up by their numbers for the chances against them.

If a tape-worm lives for two years it produces about 1,600 links, each with upward of 53,000 eggs, or, altogether, about 85,000,000; and, of course, unless the number of developed tape-worms were to increase enormously, only one or a very few of all these eggs could develop into a tape-worm.

Van Beneden says: "These tape-worms are found in all the vertebrate classes. An herbivorous animal usually serves as a vehicle, but it more frequently carries, besides its passengers, species which are peculiar to itself. As the carnivorous animal is not intended to be eaten, like the herbivora, it cannot serve as a vehicle, and if by chance its muscles enclose some passenger, he has lost his way, and that forever."

As a rule, the life of parasites is passed with two hosts; with one during youth, with another during the period of sexual maturity. Sometimes these hosts are merely different individuals of the same species.

Parasites may cause symptoms by their mere presence as foreign bodies (as rolls of lumbricoids obstructing intestines), by interfering with nutrition, and in various ways. The London *Medical Times and Gazette*, February 17, 1883, contains an article by Dr. Manson on Filaria sanguinis, and some editorial comments on the paper, calling attention to the fact that this is the first time that disease of the parasite has been shown to cause disease of its host (see article on Filaria sanguinis).

Under the head of "Protozoal Parasites," Cobbold treats of bacteria which in some shape are said to be

present in the blood of patients suffering from a variety of diseases. It seems to have been proved that various infections are due to them. It is claimed that they are the cause of anthrax, cerebro-spinal meningitis, cholera, erysipelas, diphtheria, glanders, gonorrhœa, hydrophobia, intermittent and relapsing fevers, measles, pertussis, scarlatina, small-pox, syphilis, tuberculosis, typhoid and yellow fevers, etc.

Pasteur and others assert that cultivating these bacteria in certain ways weakens, without changing, their characters; and that inoculating healthy subjects with solutions of gradually increasing activity will protect the recipient from the disease caused by the special bacteria. At present this enticing theory has hardly been sufficiently proved to justify us in accepting it fully. But should time establish it, man may defy almost everything but traumatism. *Charles E. Hackley.*

PAREIRA BRAVA (*Pareira*, U. S, Ph.; *Pareiræ Radix*, Br. Ph.). The root, and frequently the stem, of *Chondodendron tomentosum* Ruiz & Pavon, Order, *Menispermaceæ*. This is a tall, soft-wooded, large-leaved, climbing shrub, with diœcious flowers, and grape-like fruits. The leaves are broadly cordate, twenty-five or thirty centimetres long, and grayish-woolly beneath, giving, from this circumstance, rise to the specific name of the plant. The flowers are small, regular; calyx of several whorls of sepals in six rows, the outer minute, the inner progressively larger; innermost rounded, concave, imbricated in the bud. Petals six, smaller than the inner sepals; stamens six, carpels also six, embryo curved. The stamens or pistils are abortive in the fertile and sterile flowers, respectively.

This vine is a native of South America, where, especially in Brazil, it is in extensive employment as a medicine. It was first introduced to the notice of physicians in Europe about two hundred years ago, and after a period of neglect was again brought forward in the early part of this century. It is very little used at present—at least in this country. During this period there have been several other closely related products from allied genera imported as Pareira Brava, adding much to the botanical confusion in regard to its source. The "false Pareiras" appear to have about the same amount of doubtful usefulness as the genuine.

Description.—"In cylindrical, somewhat tortuous pieces, about four to six inches (10 to 15 centimetres) long, varying in thickness from three-fourths of an inch to four inches (2 to 10 centimetres); externally dark brownish-gray, with transverse ridges and fissures, and longitudinal furrows; internally pale-brown, the fresh-cut having a waxy lustre; bark thin, wood porous, in two or more somewhat irregularly concentric circles, and with distinct medullary rays; inodorous and bitter" (U. S. Ph.)

Composition.—The only definite principle obtained from this root—one, too, which exists also in the false Pareiras—is *buxine* (bibirine, pelosine), a bitter, somewhat tonic alkaloid, found also in several other plants whose parts are occasionally used in medicine.

Action and Uses.—Pareira is possibly tonic, but is never used with this property in view. It is regarded by a good many physicians as a stimulant diuretic, without very good reason; it is occasionally given in chronic cystitis, and, as is claimed, with benefit, but does not, on the whole, command much confidence. The buxine it contains does not appear to possess the qualities claimed for Pareira.

Administration.—A Fluid Extract (*Extractum Pareiræ Fluidum*, U. S. Ph.) is prepared; dose from four to six cubic centimetres (℥ j. ad ℥ ij). A decoction would also be a desirable form.

Allied Plants.—The false Pareiras have been sufficiently referred to; they all are the product of neighboring genera. The order, which is moderately large, consists principally of tropical climbers, generally bitter, sometimes narcotic and poisonous. *Jateorrhiza palmata* Miers is the source of Calumba (U. S. Ph.). *Menispermum canadense* of Canadian Moonseed (Menispermum, U. S. Ph.), and *Anamirta paniculata* Colebr., of *Cocculus indicus* Picrotoxin, U. S. Ph.).

Allied Drugs.—The uncertain action of Pareira makes these difficult to arrange with accuracy. Buchu, Uva Ursi, Cleavers, Couch-grass, and many other things are given in the same class of diseases.

W. P. Bolles

PARNASSUS SPRINGS. *Location*, Pueblo County, Col.; *Post Office*, South Pueblo, Pueblo County, Col.

Access.—By the Denver & Rio Grande Railway to Pueblo, thence by conveyance to the springs, twelve miles distant.

Analysis.—One pint contains (72° F.):

	Grains
Carbonate of soda	8.623
Carbonate of magnesia	1.624
Carbonate of iron	0.162
Carbonate of lime	3.975
Carbonate of lithia	0.129
Chloride of sodium	5.879
Sulphate of potassa	1.544
Sulphate of soda	0.236
Silica	0.467
Total	20.482

An alkaline-chalybeate water.

These springs are situated southeast of Central Colorado. There are no improvements at present. *G. B. F.*

PAROTID GLAND, WOUNDS AND NEW-GROWTHS OF. Owing to its situation, protected as it is by bony ridges, the parotid gland is not often wounded, except as it may be involved in extensive injuries of the side of the face and the jaw. Cases have been reported, however, of wounds of the gland from bullets, pieces of glass, scissors, sword-thrusts, etc. A foil has been known to enter the mouth and wound the parotid on its inner surface; in such a case, of course, the lower portion only of the gland would be injured.

The escape of saliva from the wound in this region is an evidence that the gland is injured. This, however, becomes evident only after the flow of blood has ceased. It is shown by a dribbling of a thin, colorless fluid, which is increased in amount by mastication or any movements of the jaw, and also by the presence in the mouth of any substance of pronounced taste. If the facial nerve is injured, there will be paralysis on that side, which will be complete or incomplete as the trunk of the nerve or merely one of its branches has been divided. There is usually also more or less anæsthesia on the same side of the face. This and the paralysis may disappear, but the latter will persist if there have been extensive loss of substance, as after a contused wound of the part.

Hæmorrhage, if it be small in amount and if the wound appear to be superficial, is of no significance and need occasion no uneasiness. But it is far otherwise if the flow is profuse, and if it is known that the wounding body has penetrated deeply, for the external carotid artery passes through the gland, and the internal carotid and vertebral arteries and the jugular veins lie in the immediate vicinity, where they may easily be injured by any penetrating body. It may be a difficult matter, or even impossible, to determine with certainty which one or more of these important vessels may have been injured. Wounds of the external or internal jugular may be recognized by the venous character of the hæmorrhage, and also by the fact that the flow is increased by pressure exerted on the vein below the seat of the injury. It is a more difficult problem to determine which of the three large vessels is wounded when the character of the hæmorrhage is arterial. The direction and extent of the wound should be taken into account in making a diagnosis. If the offending body has entered posteriorly, passing under the sterno-cleido-mastoid muscle in the direction of the transverse processes of the cervical vertebræ, it may be assumed that the vertebral artery is the one from which the bleeding comes. When the direction of the wound is transverse, passing from behind forward under the ramus of the jaw, it is most probable that the external carotid artery has been opened. If the penetrating body has entered deeply in the depression behind the ramus of the jaw, the resulting hæmorrhage, if pre-

fuse, is probably from the internal carotid artery. If pressure on the common carotid artery causes a marked diminution in, or arrest of, the flow, it will be possible to exclude injury of the vertebral artery; but if the bleeding is not entirely arrested by such pressure, it does not necessarily follow that the vertebral is wounded, as hæmorrhage may continue through the anastomotic branches. If the pulsations in the superficial temporal artery on the side of the injury are markedly weakened or abolished, the external carotid may be known to have been wounded; but if the pulsations are only a little weaker than those of the corresponding artery on the opposite side, no certain conclusions can be drawn, since there is often a slight difference normally in this respect between the two sides.

In wounds of the parotid gland, the first indication is to arrest the hæmorrhage. If one of the large arterial trunks is divided it will, in most cases, be necessary to resort to ligature. Sometimes, though rarely, it may be possible to seize the divided ends of the vessel and ligate them *in situ*. But, owing to the narrowness of the space in which it is possible to work, this procedure will not often be feasible, and then the vessel or vessels must be ligated in continuity. The advice and practice of surgeons differ in regard to the method to be adopted in such a case. Some advise ligature of the common carotid only, when it is one of its branches that is wounded, while others prefer to tie the common carotid and one of its branches near the point of bifurcation; others, again, advise ligation of both the internal and external carotids. It would seem better to ascertain first which vessel is injured, and then ligate that one only. If it is impossible to determine at once from which branch the hæmorrhage occurs, it has been recommended to tie first the external carotid, and then, if the flow is not arrested, to proceed to the ligation of the internal carotid. Some prefer to expose both branches, and then to ligate the one which compression has shown to be the source of the bleeding. If this does not arrest the hæmorrhage, the common carotid should be tied. In the unusual event of a wound of the vertebral artery, this vessel may have to be ligated. The artery has been ligated in the first part of its course in cases of this kind, and it has also been tied within the vertebral canal after the removal of one of the transverse processes. In the case of a wound of this artery it has also been proposed to drive a plug in between two of the transverse processes, thus compressing the vessel. In some cases of injury of one of the carotid branches the hæmorrhage may persist, even after ligation of the common carotid, through the anastomotic branches. Recourse must then be had to strong compression, cold, the thermo-cautery, and even styptics if all other means fail. As a last resort, it has been proposed to extirpate the gland so as to gain access to the collateral branches from which the bleeding proceeds. This would, of course, result in permanent facial paralysis.

When the hæmorrhage is slight and it is certain that no large vessels have been wounded, an attempt should be made to obtain union by first intention. After the wound has been carefully cleansed and all bleeding has ceased, the divided surfaces are to be approximated, and retained by sutures under an antiseptic dressing. We may, in this way, hope to secure reunion of the facial nerve, if it has been divided, and thus effect a cure of the resulting paralysis. In the case of a lacerated wound of the parotid, it has been suggested to remove a thin portion from each surface of the wound and then approximate the parts in the hope of securing primary union. Or, if this procedure is not thought advisable in a given case, the wound may be left to heal as it will, and the salivary fistula which will probably result can be treated subsequently. A fistula, however, less commonly follows a wound of the gland itself than it does a wound of Steno's duct. After the edges of the wound have been approximated and retained by sutures, the head should be bandaged so as to prevent all motion, being held slightly flexed; and talking, mastication, and other movements of the jaw should be forbidden. Only liquid food is to be allowed, and, if necessary, the patient's strength may be maintained by nutrient enemata.

Inflammation of the gland may follow a wound, especially a contusion. The symptoms will be the same as those of parotiditis from any other cause (see articles, Mumps, and Salivary Glands, Diseases of).

New-growths.—Of the benign tumors of the parotid gland there are but few which are of pure form, most of them being so-called mixed tumors, combinations of chondromata, myxomata, sarcomata, and fibromata, in varying proportions, and many also containing cysts of greater or less size. Sometimes patches of carcinomatous formation are seen within otherwise benign tumors. These mixed tumors are more frequently encountered in the parotid gland than in any other part of the body, except, possibly, the ovary.

The following table, from C. O. Weber, indicates the relative frequency with which the different neoplasms occur in this region: Enchondromata, 28; carcinomata, 26; fibro-sarcomata (mixed tumors), 20; fibromata, 6; cystomata, 5; melanotic adeno-sarcomata, 4; sarcomata, 3; myxomata, 3.

Cysts.—Simple, salivary, hydatid, dermoid, and sanguineous cysts have been met with in the parotid gland. They are, however, not very common, occurring alone, though, as stated above, they are a not infrequent complication of other tumors. Salivary cysts are seldom larger than a hen's egg; but they sometimes undergo a temporary enlargement during movements of mastication. They are seated beneath the aponeurosis, are fluctuating, slightly movable, not translucent, and non-adherent to the skin. They are more commonly single, but are sometimes multiple. Simple cysts are translucent, usually very mobile, fluctuating, of rather slow growth, and do not increase in size during mastication. When the nature of the cyst is doubtful, a portion of its contents may be removed by aspiration with the needle of a hypodermic syringe; the contents of a salivary cyst are clear, amber-colored, and slightly viscid, while those of a simple cyst are watery. Sanguineous, dermoid, and echinococcus cysts are rare, though examples of each have been seen and recorded.

Calculi may be formed in Steno's duct or in the gland itself. They are characterized by a swelling and by the presence of a hard body. When present in Steno's duct, the orifice of the duct is patulous, and the stone can often be detected by the introduction of a probe into the canal. The bodies may be removed by an incision from the interior of the mouth along the line of the duct.

Lipomata of the parotid region may be situated upon, beneath, or within the gland. They are, however, extremely rare, although the interstitial glandular tissue is moderately rich in adipose tissue. It is not very uncommon, however, to find lipomatous areas in the mixed tumors.

Angiomata are occasionally seen in this region. They are usually congenital, and are formed by the gradual dilatation of the arterial or venous capillaries, which displace the glandular tissue. They sometimes go on to the formation of cavernous tissue. An angioma presents as a pulsating tumor, which is increased in volume by crying or forced expiration, and is reduced by pressure. The treatment consists in graduated pressure, followed, if unsuccessful, by ligature of the external carotid artery. Extirpation of the growth has been recommended when other means fail.

Fibromata may exist as distinct tumors, or there may be a new-growth of fibrous tissue mixed with the normal glandular substance. They not infrequently contain one or more cysts, occurring as a result of compression of the ducts by the fibrous tissue. They are found as hard, resistant tumors, rose-colored, or of a pearly tint on section, and very slightly vascular.

Myxomata, occurring alone, are rare, but are more commonly met with in the mixed forms with enchondroma and sarcoma. They are soft, gelatinous, fluctuating masses, containing a thick, transparent fluid, which may be obtained in considerable amount by scraping the cut surface of the tumor. They may be clearly defined tumors, or may merge gradually into the neighboring tissues.

Enchondromata were formerly supposed to be very common in the parotid gland but they are not, in a pure form at least, of frequent occurrence; cartilage is, however, found in nearly all parotid tumors. Cartilaginous tumors usually appear early in life, but those of the parotid gland are said to be exceptional in this respect, appearing more commonly in early or middle adult life. They occur as firm, elastic tumors, rarely larger than an egg or the closed fist, smooth on the surface or nodulated, usually encapsulated, though sometimes adherent to the surrounding tissues, and occasionally connected by a slender pedicle to the external auditory canal. They are not infrequently found with calcareous concretions and bony formations in their interior. Extirpation of a cartilaginous tumor is usually comparatively easy of accomplishment.

Adenomata are not often encountered in the parotid gland as independent tumors, though it is not unusual to find some increase in the glandular elements along with new-growths, at least in the early stages. An adenoma may be acinous or tubular, according as the tumor has arisen from the glandular acini, or from the ducts leading therefrom. The tumor is tolerably firm, nodular, non-adherent to the skin, but usually not strictly separable from the surrounding tissues.

Sarcomata, when small, are firm in consistence; when large (they may grow to a very great size), they are soft, vascular, lobulated, and often contain cysts—cysto-sarcomata. These tumors rarely occur in a pure type, but are found mixed with cartilaginous, fibrous, and myxomatous growths. The melanotic sarcoma, which is seen exceptionally, grows with considerable rapidity, contracts adhesions with the skin, and then ulcerates.

Lymphadenomata and *lymphosarcomata* are, when of small size, hard and smooth; but when large, they may become soft as a consequence of the interstitial hæmorrhage which not uncommonly occurs. In the more advanced stages they may contract adhesions with the skin and, at a later period, ulcerate. On section the tumors are seen to be soft and grayish in color, and yield a milky fluid on being scraped; here and there are seen hæmorrhagic foci filled with black blood. The neighboring lymphatic glands may become involved in lymphadenoma.

Carcinomata are seen as epithelial, scirrhous, and encephaloid tumors. They occur later, as a rule, than the non-malignant neoplasms. The epithelial are the least malignant of the three varieties, and may exist a considerable time before involving the neighboring tissues, being of comparatively slow growth. There are two varieties, the pavement and the tubular, the latter being the more common. They form usually rather firm and elastic tumors, roundish or oval in shape, of smooth or lobular outline, and not well marked off from the surrounding healthy tissues. In the later stages the nerves, vessels, and integument become involved, and ulcerations are formed.

Scirrhous and encephaloid tumors are of much more rapid growth than the epithelial forms, and in every way display a much greater malignancy; they contract adhesions with the skin early, and quickly invade the neighboring parts. There is severe pain from the implication of the nerves, and facial paralysis is common; the attachments formed to the muscles and periosteum of the jaw render masticatory movements difficult; and the skin becomes ulcerated, the ulcers presenting exuberant granulations which bleed easily, and are the source of a foul, ichorous discharge. The cancerous cachexia is early developed, and the prognosis is bad, the only hope, and that a poor one, being in extirpation of the neoplasm at its very commencement.

The *diagnosis* of tumors in the parotid region is not always easy, and it is sometimes even difficult to determine whether the gland is involved or not. Tumors originating in the gland push up the lobe of the ear and may, at the same time, be felt from the mouth. The benign tumors grow much more slowly than do the malignant ones, though even the latter are usually less rapid in their development than are similar neoplasms in other parts. The malignant growths more quickly form adhesions with the neighboring tissues, though even the benign tumors contract adhesions after a time: the latter, however, do not usually involve the skin or go on to ulceration. The benign tumors appear earlier in life, as a rule, than do the cancerous growths, the latter seldom affecting individuals under forty years of age.

The *treatment* of tumors of the parotid gland consists in partial or total extirpation. In order to be of avail, it must be done early, before adhesions have been formed with the neighboring parts, as after this has taken place little permanent benefit can be anticipated from operative measures. It is often impossible, indeed, even in the early stages, to remove the whole of the new-growth, especially when it has originated in the lower portion of the gland, by reason of the proximity or involvement of the large vessels and the trunk of the facial nerve. The operation is very difficult at the best, and it is impossible to avoid injury to some of the branches, at least, of the facial nerve. The knife, galvano-cautery, or écraseur may be employed according to the judgment of the operator, and the indications in each individual case. Simple cysts may be treated by removal of the fluid and the injection of tincture of iodine or carbolic acid, by the introduction of a seton, or, finally, by extirpation of the sac. In the case of a salivary cyst, if it is impossible to relieve the obstruction, it may be opened through the mouth, with the result of establishing a permanent salivary fistula. Pressure is sometimes efficacious in reducing the volume of an angiomatous tumor, thus obviating the necessity of an operation.

The following authors, among others, have been consulted in the preparation of this article:

Chrétien, H.: Article Parotide, in Dechambre's Dictionnaire Encyclopédique des Sciences Médicales.
Decorme, Edmond: Article Parotide, in Jaccoud's Nouveau Dictionnaire de Médecine et de Chirurgie.
Gurlt, E.: Article Gesicht, in Eulenburg's Real-Encyclopädie, 2d edition.

Thomas L. Stedman.

PAROVARIUM. The parovarium (Syn., paroöphoron, epoöphoron, corpus pampiniforme (Wrisberg) organ of Rosenmüller) in the human female, is a structure having a vertical diameter of 15 to 25 mm. (three-fifths to one inch), and consists of twelve to eighteen tubes situated in the broad ligament. They stretch between the Fallopian tube and the ovary. Taken together they present a fan-shaped, triangular appearance, the tubes converging toward the hilus of the ovary. These tubes run separately, having a straight or winding course. They are blind at both extremities, and appear to be united at their Fallopian extremities by a duct-like structure running parallel to the Fallopian tube. This tube may be continued for some distance toward the uterus in the broad ligament. The above tubes are 0.3 to 0.5 mm. in diameter, composed of fibrillar connective tissue, and lined with a single layer of ciliated epithelial cells. The whole structure is the remains of that portion of the Wolffian body from which the ovary and testis are developed. In the human subject the tubes do not penetrate the tissue of the ovary. In the dog they are found embedded in the ovarian stroma, and here are lined with flat epithelium (Waldeyer). *Henry Koplik.*

PARSLEY (*Persil*, Codex Med., root, fruit, and fresh leaves). *Carum Petroselinum* Bitt. (*Petroselinum sativum* Hoff. *Apium sativum*, etc.). Order, *Umbelliferæ*. A biennial, South European herb, which, in a cultivated form, with curled leaves, is a common table flavor and garnishing salad. All parts of the plant have long had a reputation for medicinal virtues. The fruits are of about the same size and shape as those of anise, but smoother, with a peculiar strong aromatic odor and taste. The leaves are sharp and pungent, and bitter also. The root, which is white, spindle shaped, about as large as the finger, is milder and sweetish.

From the seeds about two and a half per cent. of clear white or yellow *essential oil*, of the characteristic odor and taste of the plant, is obtained. It consists chiefly of

a *stearoptene* ("Parsley camphor") and a *hydrocarbon*. They contain also a large quantity of *fat*, and considerable *resin*. *Apiol*, which has had a reputation as tonic, emmenagogue, and antiperiodic, is a purified ethereal extract from parsley fruits, and consists of the above oil, resin, and perhaps some fat. It is a colorless or yellow, oily, inflammable liquid, of strong parsley-like odor and sharp taste. Sp. gr. 1.08; reaction acid. In the leaves, besides volatile oil, a neutral, inactive substance, *appiin*, is found. The root is milder than the fruit and leaves. It contains a little *essential* oil, tannin, mucilage, sugar, etc.

Parsley has an analogous composition and properties to other carminative *Umbelliferæ*; parsnip, for instance. It is aromatic, perhaps diuretic, and slightly antispasmodic. Apiol and some other preparations of Parsley have been praised as antiperiodic, febrifuge, emmenagogue, etc., but have no special right to such reputation.

Dose, of Parsley Oil, as a stomachic, from five to ten drops; of Apiol, about the same, in emulsion on sugar or in capsules.

Allied Plants.—*Celery* (*Ache des Marais*, Codex Med.). *Apium graveolens*, cultivated in Europe for its root, here for its leaf-stems, is also employed to a slight extent in medicine. Its seeds contain considerable rather pleasant *essential oil* of similar qualities to that of Anise. Celery is also considered to be soporific, and is perhaps slightly so, but its powers in this direction are feeble. See Anise.

Allied Drugs.—See Anise, and other *Umbelliferæ*.

W. P. Bolles.

PASO DE ROBLES SPRINGS. *Location and Post Office*, Paso Robles, San Luis Obispo County, Cal.

Access.—By railroad, Southern Pacific, from San Francisco to Soledad; thence by stages to the springs, twenty-one hours from San Francisco.

By steamer from San Francisco every three days to Port Harford; thence by cars to San Luis Obispo, nine miles, from which place either by stage or carriage to the springs, thirty miles.

Analysis (Professor Thomas Price).—One imperial gallon contains:

	Main Hot Sulphur. 110° F. Grains.	Mud Spring. 122° F. Grains.
Sulphate of lime	3.21	17.90
Sulphate of potassa	0.88	traces
Sulphate of soda	7.85	41.11
Peroxide of iron	0.36	traces
Carbonate of magnesia	0.92	3.10
Carbonate of soda	50.74	5.21
Chloride of sodium	27.18	96.48
Iodides and bromides	traces	.....
Alumina	0.22	traces
Silica	0.44	1.11
Organic matter	1.64	3.47
Total	93.44	168.38
Gases.	Cub. in.	Cub. in.
Carbonic acid	10.50	47.84
Sulphuretted hydrogen	4.55	3.28

There are, besides the above, three cold sulphur, three other hot sulphur springs, and one chalybeate.

Therapeutic Properties.—These are valuable alkaline-sulphur thermal waters. They are very efficacious as baths in chronic diseases of the skin, rheumatism, etc. A competent physician directs the treatment at the springs.

The springs are situated in the southwestern part of California, on a gentle slope from the foothills of the Coast Range to the banks of the Salinas River. The valley is covered with groves of white and live oaks, "Paso de Robles" meaning "Pass of Oaks." Although only sixteen miles from the Pacific Ocean, the elevation is one thousand feet. The ever-verdant mountains are barriers against the damp sea-fogs and cold north winds, and, altogether, this is one of the most delightful and restorative resorts in America. The hotel and numerous cottages afford first-class accommodation. There are both public and private bath-houses, and two large plunge-baths, one for men and one for women.

George B. Fowler.

PATELLA, INJURIES AND DISEASES OF THE. Anatomy.—The patella is said to resemble the sesamoid bones, from the fact that it is developed in the course of the quadriceps extensor tendon; and further, because of its structure, being composed of dense cancellous tissue. It is generally regarded at the present day, however, as being analogous to the olecranon process of the ulna. This analogy is further borne out by the fact that the latter occasionally exists as a separate bone, being connected to the shaft of the ulna by a prolongation of the triceps muscle. The patella, like the olecranon, also serves as a means of increasing the leverage of the extensor muscles to which it is attached, by compelling them to act at a greater angle. It also serves to protect the anterior surface of the knee-joints.

It is small, flat, and triangular in shape, with the apex downward. Its anterior surface is separated from the integument by the interposition of a bursa, is convex, and perforated by small openings for the passage of nutrient arteries, and is marked by a number of striæ running in a longitudinal direction. The quadriceps extensor tendon is attached to its broad upper surface or border, as well as to its anterior surface and lateral borders. The apex or inferior angle, together with a rough convex depression on its posterior surface, serves for the attachment of the ligamentum patellæ. Its posterior, deep, or articulating surface is covered in the recent state, with the exception of its extreme lower end, with cartilage. It is marked by two facets, separated from each other by a vertical ridge; the external of these facets, adapted for articulation with the external condyle of the femur, is transversely concave and is the broader and deeper of the two; the internal facet is smaller and is convex.

In its structure the bone consists of condensed cancellous tissue, covered by a thin but compact lamina. In its development, according to Béclard, there is but a single centre of ossification, which becomes apparent at about the third year. Occasionally, according to Gray, the bone is developed from two centres, placed side by side.

Overlying the bone, or placed between its surface and the overlying skin, is a bursa belonging to the class known as the bursæ mucosæ. It encloses a clear, viscid fluid, and has for its office the prevention of friction in the gliding of the integument over the projecting bony surfaces.

During life the patella, when the limb is in a longitudinal position, lies loosely in the quadriceps extensor tendon when the muscle is relaxed. It can be moved from side to side, and both upward and downward, by passive movements. The leg may be flexed to an angle of 130° before the bone becomes fixed and immovable.

Ostitis of the Patella is a rare disease, and when it does occur is found in conjunction with similar diseases of the femur or of the tibia. Extension of inflammatory action from a bursitis of the prepatellar bursa will also account, occasionally, for its presence.

Caries and Necrosis.—Carious disease of the patella is, according to Erichsen,[1] the result, occasionally, of a suppurative bursitis of the prepatellar bursa. This surgeon records the case of a patient, a female, who, when admitted to the hospital, had several fistulous openings upon the anterior surface of the knee-joint, which had not been incised with sufficient freedom. The probe led to a diseased patella, and a free incision revealed a carious condition of this bone. Violent suppurative inflammation of the knee-joint followed a gouging operation with the view of removing the diseased bone, and the limb was finally amputated. The late Dr. John O. Stone,[2] of New York, relates an interesting case of abscess of the thigh, complicated with caries of the patella, occurring in Bellevue Hospital in 1853. It is difficult to determine, from the report of the case, which condition preceded the other. At a consultation of the surgeons of the hospital, it was decided to amputate the limb. The patient died from the operation, and Dr. Stone adds this note to his report of the case: "On examining the joint after the operation, it was found that the patella alone was carious, and that the rest of the limb was sound. Thus amputation was performed and a life sacrificed for a carious patella."

The rarity of these cases induces me to report a case coming under my own observation. A woman, about fifty years of age, was admitted to my service at St. Mary's General Hospital, Brooklyn, with the following history. About twenty years before, she had suffered a fracture of the patella upon the right side. Rather short ligamentous union of the patellar fragments and fibrous anchylosis of the knee-joint followed. The day before admission she had fallen and ruptured the ligamentous tissue uniting the fragments, and at the same time broke up the anchylosis. Severe intra-articular inflammation followed. After this had subsided, the joint was opened, the remains of the old ligamentous connecting-band dissected away from the fragments, and the wire suture applied. Everything went well for the first week, union of the soft parts being almost completed, when a severe cellulitis of the anterior region of the knee-joint occurred; suppuration followed, and several sinuses persisted, in spite of free incision and drainage. Antiseptic measures were persevered in, however, in spite of the unfavorable conditions, and finally the knee-joint was again opened, when the patella was found to be carious. The greater portion of the bone was gouged away, the articular extremities of the tibia and femur being brought into view during the operation. The case was still treated in a thoroughly antiseptic manner, and the patient left the hospital, in a few weeks afterward, with the sinuses healed and the limb, according to her own statement, in as good condition as at any time during the preceding twenty years, or since the occurrence of the first accident. There existed no greater amount of anchylosis of the knee-joint than before the operation.

The existence of an ulcer over the knee-joint, in a broken-down or cachectic individual, is sometimes the occasion of caries of this bone. In these cases the ulceration extends to a depth sufficient to bare the bone, and the latter softens and becomes involved in the destructive action. Some slight accident, or unusual muscular exertion in an unguarded moment, produces a fracture of the bone, and, if the ulceration of the soft parts is extensive, they, too, are torn across, laying the knee-joint completely open. An instance of this is also recorded by Dr. Stone.[3]

Syphilitic disease of the patella, although rare, occurs with sufficient frequency to warrant mention. It may result in molecular death of bone (caries), or death *en masse* (necrosis). An ostitis or periostitis, or both, may occur, due to the syphilitic poison, and destructive changes in the bone not occur. An instance of this kind is mentioned by Mr. Howard Marsh,[4] in which the bone was very considerably enlarged in all directions, painful, and tender.

Necrosis of the patella occurs most frequently as a result of compound fracture of the bone. In a case of this kind which occurred in my hospital service, the entire upper fragment necrosed and required removal. The case, however, recovered, with excellently good use of the limb.

The importance of early operative interference in cases of suspected caries or necrosis of the patella must be apparent at once. The dangers of delay, even in abscess of the lower part of the thigh, or where old sinuses exist, cannot be overestimated. Exploratory puncture, with antiseptic measures, incision, and free drainage, or gouging with Volkmann's sharp spoon, if the bone is found to be diseased, with, in proper cases, total excision of the bone; these, in short, constitute the only measures to be regarded as at all safe in dealing with the cases under study.

Tumors of the Patella.—Fibrous tumors may occur in the neighborhood of the patella in connection with the mucous bursæ. Chelius[5] writes concerning this class of growths: "The mucous bursæ are apt to undergo degeneration, their cavity may become the seat of a firm fibrous mass adhering to their walls, which mass may gradually grow to a large circumference. I have observed tumors of this description, which I have successfully extirpated. Any other treatment is of no avail."

Brodie,[6] in the chapter on chronic inflammation of the mucous bursæ, says that in the beginning the walls of the inflamed mucous bursa are thin, and the fluctuation of its contents is distinctly perceptible. But, if of long duration, there will be seen a thickening of the walls of the mucous bursa, so that the latter will take on all the properties of a firm tumor. In one case where the mucous bursa enlarged to the size of a small orange, it was necessary to remove the growth by an operation. The walls of the growth were found to be half an inch thick, and of a fibrous character, but the interior had preserved its cellular condition, containing a serous fluid.

Bryant[7] states that the deposits in the bursæ patellæ are fibrous, being either of a vesicular structure or formed in layers, and this is gradually transformed into a nearly solid tumor. He points especially to the fact that he is not acquainted with any case where a completely solid tumor formed, but, on the contrary, all that he met with had a cavity in the centre. This has not been the experience of surgeons generally, solid fibrous tumors being the commonly described variety of growth in this location, as well as osteo-sarcoma and sarcomatous neoplasms.

Ferguson[8] speaks of having observed and removed sarcomatous growths in the neighborhood of the prepatellar bursa. This author, however, is of the opinion that these growths, as a rule, occur independently of the mucous bursa, although, exceptionally, he states, they may develop in one side of the bursa.

Miller[10] mentions fibrous tumors in the surroundings of the patella, and dismisses the whole subject in almost a word.

Erichsen asserts that solid tumors may form in connection with the bursa patellæ. In cases coming under his observation the tumor did not seem to be a simple result of a hydrops bursæ patellaris, or common housemaid's knee, but rather a fibrous deposit in the bursa itself, commencing as such. He speaks of the possibility of the tumor being of a syphilitic origin.

Lienhart[11] describes two forms of chronic inflammation of the bursa patellæ, namely, hygroma and fibrous degeneration. This author saw, as a consequence of long-continued kneeling, a tumor develop over each ligamentum patellæ the size of a fist. Another, which he removed from a servant-girl, thirty-five years of age, contained a yellowish, slightly transparent fluid.

It would seem that Erichsen is alone in the belief that fibrous tumors in the neighborhood of the patella are never caused by pressure.

Nélaton,[12] although a surgeon of large experience, does not seem to have met with this class of growths. He remarks, however, that the walls of the sac of a diseased bursa patellæ may have its walls thickened by the formation into layers of fibrous material following an effusion of blood.

Follin[13] describes the formation of a fatty tumor, the result of a peculiar derangement of the mucous bursæ, but makes no mention of fibrous tumors of the patella.

Bardeleben[14] is conversant with tumors here referred to, and gives it as his opinion that acute inflammation of the bursa generally leads to the chronic variety of the disease. Thickening of the walls will develop and continue. The fluid contents, he observes, are difficult of recognition.

The space devoted to tumors of the patella in standard text-books of pathological anatomy is still less than that in surgical works. Gurlt's[15] observations upon the subject simply amount to the statement that the layers of fibrous material completely obliterate the enlarged mucous layer.

Rokitansky[16] states that mucous bursæ, and particularly the bursæ of the patella, are found to be completely filled by a fibrous and gelatinous mass of connective tissue.

Foster states that thickening of the walls of the bursæ and complete obliteration of their cavities by connective-tissue deposits occur.

Virchow[17] gives no explanation of the causation of these growths. He describes a hæmatoma of the prepatellar bursa, and gives an illustration of the same.

Mettenheimer[18] has probably written the most elaborate treatise upon tumors in the neighborhood of the patella. He gives the history of a case in which a tumor existed over each patella. The patient, a scrub-woman,

was unable longer to follow her occupation on account of the distress occasioned by kneeling. The larger one of the two growths was two years in developing, the smaller one a little over a year. No inflammatory symptoms preceded their development, which was painless. There was no history of syphilitic infection. Both growths were excised, and very carefully examined. The tumor of the left patella was the smaller of the two, and looked like a large ganglion. Upon section it proved to be a solid mass of a faint-red color, the latter changing here and there to yellow. Delicate, wave-like striæ were mainly visible, some of these being in a concentric direction, while others crossed each other near the periphery. No cavity existed in this tumor. The larger tumor, before it was incised, seemed to give an uncertain feeling of fluctuation. Upon section the centre of the tumor contained a small quantity of a yellowish viscid fluid, similar to the fluid contained in ganglia. The cortical portion of this growth resembled the substance of the smaller growth removed from the other patella. Both tumors mainly consisted of fibrous tissue in different degrees of development. The histological elements existing in the fluid contained in the cavity of the larger growth resembled somewhat those which, according to Frerichs, are present in the synovial fluid.

Mettenheimer is inclined to include the growths which he removed under the head of ganglia, and gives a number of reasons in support of this view.

Behrens[19] reports the case of a servant-maid whom he was called to attend, suffering from a severe pain, upon walking, in the left knee-joint. An examination revealed a flattened, rather hard, yet movable tumor, the size of a hen's egg, upon the patella. The integument covering the enlargement was normal. She dated the commencement of the difficulty to a contusion received three months before; the case was regarded as a chronic inflammation and thickening of the bursa of the patella. Local applications failing to affect the growth, extirpation was advised, and executed. The tumor was found to be but slightly adherent, and consisted apparently of partly organized blood-clot. Although the hæmorrhage during the operation is not described as being unusual, yet within twelve hours a most profuse bleeding took place from the operation-wound, necessitating the use of the actual cautery, finally, for its arrest. A subsequent incision, made in the groin, to evacuate an abscess, bled, after about four hours from the time of the incision, most profusely. This case is to be regarded as one of hæmorrhage into the cavity of the bursa, as the result of an injury occurring in a patient with the hæmorrhagic diathesis.

A tumor somewhat similar to this is the one reported by M. Denonvilliers.[20] It was situated on the right knee, under the ligament of the patella, as well as under the bone itself. It consisted of a mass of fibrinous material, and seemed to be a sequel to an old effusion of blood in the part. It did not communicate with the cavity of the knee-joint. The growth caused considerable pain at times, and, at the earnest solicitation of the patient, it was excised.

Dr. Martinez[21] reports the case of a woman upon whose right knee there developed a tumor, evidently traceable to excessive kneeling. The patient abandoned the occupation, but the tumor continued to grow until it reached the size of a child's head. The integument covering it became inflamed, and this, together with the inconvenience occasioned by its weight, led her to seek relief. It was removed by excision, and was found to be intimately connected with the patella itself. It contained a cavity filled with a dark, chocolate-colored fluid. No record is made of the histological character of the growth, save the statement that it was adherent to the patella by a net-work of fibro-cartilaginous tissue, and that the same structure existed in its walls, which latter measured about an inch and a half in thickness.

Dr. D. Melcot Sanchez Toca[22] reports the case of a female, aged thirty, from whom he removed a fibro-cartilaginous tumor from the anterior inferior portion of each patella. The growths, in this case, were situated upon the ligamentum patellæ, near its insertion into the bone, simulating the sesamoid bones. Mention is made of the existence of a fibro-cellular capsule, which permitted of the ready enucleation of the growths.

Cysts pure and simple may develop in this region. M. Courtin[23] reports the case of a chimney-sweep, forty years old, who entered the hospital of St. Antoine with a cystic tumor the size of a child's head at full term. The cyst dated back to the age of fifteen years, and was apparently the result of a fall. Three days before his admission to the hospital a spontaneous opening took place in the tumor, and a considerable quantity of transparent fluid was discharged. The growth was extirpated, and had a circumference of 24 ctm. at the pedicle and 36 ctm. at the bulging part. Its walls were very thick, and resembled cartilage in hardness.

Cruveilhier expressed the opinion that this tumor was an elephantiasis-like or hypertrophied hygroma.

Osteosarcoma may attack the patella and attain an enormous size. Michon[24] relates the case of a mechanic who, five years previously, had suffered transverse fracture of the patella, which seemed to occupy longer than the usual period of time in repair. For the last five months of its existence it had grown with great rapidity, and finally enveloped the entire knee-joint. The limb was amputated at the thigh. Examination revealed the fact that this tumor was united to the patella, and that small secondary growths of a malignant nature occupied the upper part of the tibia.

The same surgeon[25] reports another case of osteosarcoma of the patella, occurring in the person of a locksmith, aged forty. This patient had suffered a contusion of the patella, and subsequently, about twelve years prior to his admission to the hospital, a fracture of the same bone. This knee, from that time, continued to be larger than the other. The growth attained a circumference of about 32 ctm. Amputation was performed in this case also. Upon dissection the tumor was found to be filled with pus, detritus, and semi-liquid blood; in the centre the fractured patella was found surrounded by hard, white, and pearl-colored tissue, creaking under the scalpel. Microscopical examination by M. Robin showed it to be of a malignant nature.

Fracture of the Patella.—The most common form of injury to which the patella is subject is fracture.

Fig. 2760.—Longitudinal Section through Centre of Artificially Fractured Patella. The upper portion of an artificially produced fracture of the patella is here shown, the lower fragment having been torn from its prepatellar attachments in order to show the latter. Drawn from an actual specimen taken from a male subject fifteen years of age. (After Macewen.)

This may be simple, compound, or comminuted. As regards the direction of the line of fracture, it may be either transverse, longitudinal, or oblique, these being mentioned in the order of frequency of their occurrence. The longitudinal variety, or even the oblique, may, and probably does, result from direct violence.

Transverse fracture, or that which traverses the bone in a horizontal direction, is by far the most common of the fractures of this bone. It was formerly thought that this great frequency was due to the fact that the aponeurotic expansion of the vasti muscles and other fibrous structures upon its anterior surface were thinnest at its central portion. Macewen,[26] of Glasgow, has shown, by a series of careful dissections, that this is an error. In fact, as a result of his observations, he determined that the prepatellar structures, at the period of life when fractures of the bone occur most frequently, are actually thicker at this point than at any other. The fibrous structures upon the anterior surface of the patella, and particularly the aponeurotic extension of the vasti muscles, run in a distinct band over the front of the bone in adult and middle life (see Fig. 2760).

That violent contractions of the powerful muscles of the thigh produce transverse fracture of this bone is true, in all probability. Even with this knowledge it has not been clearly explained, heretofore, just how the bone is broken. The accident most frequently happens while the patient is attempting to save himself from falling, the knee being in a semiflexed position. By the sudden and powerful development of the retractile force of the quadriceps extensor muscle the patella is jerked upward from its normal position, where it lies supported laterally by the patellar surface of the femur. The ligamentum patellæ holds the bone securely in a position resting upon its posterior vertical ridge, and this latter becomes the point upon which is exerted the accumulated energy, or strain, of two opposing forces; these being the weight of the body exerted through the ligamentum patellæ upon the lower half of the bone, and the force of contraction of the most powerful muscle, or group of muscles, in the whole body. A glance at the diagram (Fig. 2761) will serve to illustrate this point.

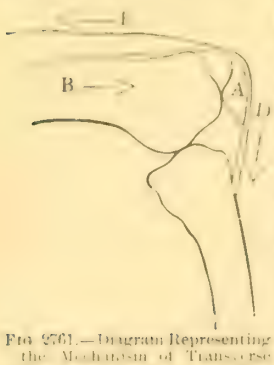

Fig. 2761.—Diagram Representing the Mechanism of Transverse Fracture of the Patella. (After Macewen.)

The bone gives way suddenly, and at times with an audible, distinct snap. Almost immediately the limb becomes useless, and upon examination a gap, more or less distinct, will be found to have developed upon the anterior surface of the knee-joint. It is believed that the prepatellar structures, being more elastic than the bone, do not give way at the same time, but at first stretch to their utmost, and finally separate by a tearing lesion so as to form longitudinal strips; the separation takes place upon a lower plane than that of the fragments of the broken bone. As the latter snaps, and its upper fragment is drawn by the now irritable extensor muscle, the aponeurotic structures overlying the bone at first bridge over the gap until the strain becomes greater than they can bear, and, as above stated, they part. This parting of the fibrous tissue in front of the knee-joint occurs probably in the large majority of cases; but, exceptionally, either the whole force is exerted upon the bone, or the stretching continues until the strain is relieved, and the tissue does not part. It is in this class of cases that but slight separation of the fragments occurs, and the disability is not immediate nor complete.

In the cases in which the rupture of the prepatellar tissue occurs—and, as before stated, these constitute the great majority of cases—the shreds of inelastic fibrous tissue, elongated so as to lose their resiliency by the strain to which they have been subjected before tearing, become entangled in the rough, fractured surfaces, particularly that of the upper fragment. This is further favored by a tilting forward of the latter, owing to the manner of insertion of the quadriceps; the plane of the fractured surface is presented thus to the strips of torn tissue, while the latter are still further forced upon the projecting spicules by atmospheric pressure (Figs. 2762 and 2763). In these instances in which the bridge becomes greatly overstretched, yet does not give way, the relaxed structures, upon extension of the leg to facilitate approximation of the fragments, are found to have become interposed between the fragments, as evinced by failure, even under an anæsthetic, to obtain crepitus (Fig. 2764).

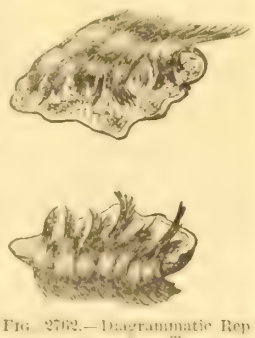
Fig. 2762.—Diagrammatic Representation of a Transverse Fracture of the Patella. The fractured surfaces are seen from before, with shreds of ruptured aponeurotic tissue overhanging them. (After Macewen.)

I have had the opportunity of verifying these observations of Macewen's, particularly as regards the complete rupture of the aponeurotic structures, upon the living subject, in recent fracture of the patella, by ocular inspection of the imprisoned fibres, clinging to the ragged surfaces of broken bone.

The location of the line of fissure in transverse fracture is usually below the centre of the bone, the lower fragment being generally the smaller of the two. In comminuted fractures either of the fragments may be again broken in a longitudinal or oblique direction. Multiple or comminuted fractures are, as a rule, the result of violence directly applied.

Fig. 2763.—Longitudinal Section of a Transverse Fracture of the Patella, representing the ruptured aponeurotic tissues arranged as in Fig. 2762, the continuity of the tissue, however, has been elevated from the bone. (After Macewen.)

In longitudinal or vertical fracture the bone parts in its long diameter. It is probable that the vigorous muscular contraction contributes to this fracture by pulling the patella upward, as shown in Fig. 2761, and at the same moment it is struck a sharp blow in front by a fall upon the knee. It is found that but slight separation of the fragments occurs; in fact, but a mere fissure may exist. The disability may not be complete; in fact, it is only relatively so in most cases of this variety of fracture. In vertical fracture the line of fissure may be either in the median line of the bone, or to one or the other side of the same. In the oblique form of the injury the cases coming under the writer's observation have had the line of fissure running diagonally across from the lower and outer to the upper and inner angles of the bone.

In cases of oblique fracture this feature of slight separation of the fragments and consequent ability on the part of the patient to walk quite a distance is likewise present. In a case of this kind which came under my care at St. Mary's General Hospital, Brooklyn, the patient walked several blocks from the scene of the accident in New York City, crossed the ferry, boarded and alighted from two different street-cars, reaching home unaided. He was brought to the hospital the next day, when it was found he had suffered a complete, although oblique, fracture of the patella on the right side. In this case bony union occurred. A similar case has since fallen under my observation. It would seem that the force, where the line of fracture runs obliquely, is expended principally upon the bone lesion, and that the aponeurotic expansion of the vasti muscles, which extends along the side of the patella, as well as the fibrous tissues upon its anterior surface, escapes the extensive injury found, as a rule, after transverse fracture.

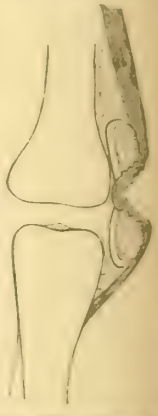
Fig. 2764.—Diagram Illustrating a Longitudinal Section of a Transverse Fracture of the Patella, with shreds of overstretched aponeurotic tissue extending in continuity from proximal to distal fragments, and dipping down between them. (After Macewen.)

It is a well known fact that after fracture of the patella there exists a predisposition to fracture of the bone of the opposite side. This occurs particularly in cases where there is more or less impairment of function due to long ligamentous union between the fragments. This predisposition will probably be found to be in direct proportion to the disability present. It is needless to say that it is especially in cases of transverse fracture that this predisposition is marked.

In considering further the pathology of fracture of the patella, attention may be called to the fact, so generally known, that union by bone, in the transverse variety of fracture at least, has been, up to a very recent date, of very rare occurrence; union by ligamentous or fibrous

tissue taking place instead. The first thing to suggest itself as a cause of this failure is the persistent separation of the fragments. As a matter of fact, up to a very recent date this was looked upon as the sole reason for the substitution of fibrous for osseous union in fracture of this bone. Macewen, however, has shown that another and a very important element enters into the causation of this sequence. That persistent separation of the fragments is of considerable importance in determining the length of the ligamentous connecting-band there can be no doubt. In addition to the force of contraction which originally produces the fracture, followed by the contractions, the result of irritability of the muscle, and the retraction of the latter, a far more serious obstacle remains after these have subsided, which latter occurs after a day or two. I refer now to the effusion of fluid into the joint, the occurrence of a hæmarthrosis, or both. It may be stated as a general proposition that the greater the amount of effusion the greater will be the separation of the fragments, and consequently, the greater the length of the fibrous tissue formed between the fragments. What, in the very first hour of the fracture's existence may have been a mere fissure, usually has developed into a wide gap by the time the patient falls into the hands of the surgeon, so rapidly does the effusion take place. The serous effusion does not, as a rule, remain long enough in the joint to prevent union by bone, and an effusion of blood, by its mere presence, would be quite unlikely to produce this effect; on the contrary, it would be of service, rather than otherwise, in that it would form a medium in which osteoblasts might form.

Deficiency of blood-supply, it has been claimed, is the cause of the great frequency of non-union in transverse fracture of the patella. Here the facts are entirely against the assumption that there is a deficiency of blood-supply to the patella. Injected specimens of the vessels going to the patella, as well as those coming from that bone, show that the blood-supply from its numerous vessels is abundant; and the parenchymatous hæmorrhage which occurs from the cancellous tissue in transverse fracture is a proof not only of its large blood-supply, but of a through distribution of the latter. The fact that osseous union is so commonly obtained in longitudinal fracture of the bone is a sufficient argument against this theory, and if anything further were needed, the abundant deposit in certain diseased states of the bone would settle the question beyond a doubt. It is likewise observed that there is not a deficiency of blood-supply in these cases sufficient to prevent the formation of connective tissue; and inasmuch as the ossific deposit occurs from the connective-tissue formation, no further proof can be required regarding the fallacy of this view.

Macewen claims, as above stated, and there can be no reason, in the light of his conclusive investigations upon the subject, to conclude otherwise, that when, in the case of a transverse fracture, the bone gives way the fibrous and aponeurotic structures over it do not give way at the same moment, but temporarily bridge the interspace then existing between the fragments. With a continuance of the force these finally give way; the breach thus formed, as a rule, is not upon the same level as that in the bone itself. The strain upon these structures prior to their giving way overstretches them, their natural resiliency is lost, they remain elongated, and their irregularly shaped extremities and surfaces are forced between the fragments and upon the rough surface of broken bone. Here they become entangled in the upper fragment, principally, although some are found clinging to the lower fragment. The osseous spicula hold them firmly in contact with the bone. It occasionally happens that the floor of the patellar bursa is also torn and falls into the hiatus between the fragments. No one can fail to see how the interposition of such tissues between the fragments must almost necessarily prove an insurmountable barrier to bony union.

It may occasionally occur, as before stated, that the bone is broken and the prepatellar structures are not greatly stretched or do not give way. In such an event bony union probably occurs; this will account for those cases of indubitable union by bone, under ordinary treatment, as demonstrated by post-mortem examination. It also happens, doubtless, that not all of the aponeurotic and fibrous tissues give way; some of them may remain intact.

Diagnosis of Fracture of the Patella.—The diagnosis of fracture of the patella is not, as a rule, attended with difficulty. In the transverse variety, at least, the true state of affairs is discernible at a glance. Here the history of the accident, the sudden and complete loss of function of the quadriceps extensor muscle, the bulging of the synovial sac, a displacement of the fragments and their wide separation, all point unmistakably to the nature of the lesion.

Crepitus, as a rule, is rarely elicited in transverse fracture, owing to the interposition of the soft parts between the fragments, as well as to the retraction of the upper fragment. In the oblique and vertical varieties of the injury crepitus may be obtained, inasmuch as the fractured surfaces lie directly in contact, neither muscular contraction nor effusion within the joint separating them, owing to the fact that the aponeurotic and fibrous structures overlying the bone are untorn; hence there exists the merest fissure. This latter, however, is sufficiently distinctive, and when taken in connection with mobility of the fragments, usually obtainable, suffices to establish the diagnosis.

Prognosis of Fractures of the Patella.—If we except cases in which a fracture of the patella is treated by opening the joint and removing any loose portions of torn fibrous tissue from between the fragments, and subsequently bringing together the divided ends and wiring them, and the rare instances in which the apposition of the bony surfaces is obtained because of the absence of shreds of torn prepatellar fibrous tissue, and cases of oblique and longitudinal fracture, it is fair to say that a limb the subject of this accident never becomes as functionally perfect as before. After many years, and when patients are apparently able to walk with perfect ease, it will be found, upon attempting to perform such movements as are accomplished by the quadriceps extensor muscle exclusively, as, for instance, bringing the foot forward with the knee held rigid, that for the reason that the quadriceps extensor alone can keep the knee extended while the foot is being brought forward, the patient will be unable to accomplish this movement without bending the knee. Again, in cases of this kind, if the patient is placed in the recumbent position and asked to raise the limb from the bed without bending the knee, he will not be able to do so. In other words, in these cases the quadriceps extensor muscle is decidedly and permanently crippled, although in time the patient, it is true, makes up for this loss by means of the psoas and adductors; he may thus experience no great difficulty in walking. The patient will be able, for instance, to mount a staircase quite readily and in the ordinary way, by having but one foot on the stair at a time; but when he attempts to descend, he is usually compelled to have both feet at the same time upon the stair at each successive step. In this way alone it will frequently be possible to detect without difficulty the fact in a given case of ligamentous union after fracture of this bone. Patients may claim that they have good use of the limb, but the above test, that of bringing the limb forward without flexing the limb at the knee-joint, will almost invariably reveal an old fracture. They have simply learned in an unconscious manner to supply the defect of contraction.

This condition of permanent inability to perform the normal movements of the leg may be due to an injury to the quadriceps muscle itself, and care should be taken, in estimating the final result in transverse fracture, to give due consideration to the possibilities of atrophy, and consequently progressively increasing disability. It is a well known fact that the muscles become insufficient quite readily after injury. To this must be added the rest and non-usage necessary for union of the patella. There is reason to believe that such a condition of the quadriceps interferes with the full use of the power of

extension with much greater frequency than is generally supposed. Von Bergmann[27] even goes so far as to assert that the injury to the quadriceps is responsible for inability to extend the leg, after transverse fracture, in a larger number of cases than is incomplete consolidation.

The extent to which the fragments are separated does not always seem to govern the amount of loss of function, although it is quite true that cases in which there is very close approximation of the fragments are more apt to recover with relatively useful limbs. On the contrary, however, the cases in which there is great separation of the fragments are not always the most unfavorable, as regards usefulness of the limb. Those cases are the most favorable in which there is a development of fibrous structures, the result of the efforts at repair, upon the sides and on the posterior or articular surfaces of the fragments, disposed in such a manner as to keep the fragments in a position approximating the normal; or, in other words, to prevent them from tilting when the quadriceps contracts. Force transmitted through the ligamentous connecting band to the ligamentum patellæ under these circumstances, will approach somewhat to that exerted in health. On the other hand, when the principal, or perhaps only, attachment of the ligament of union is at or toward the anterior surface of the fragments, when the quadriceps contracts the fragments will be tilted against the articular surface of the lower extremity of the femur, and in this way much of the force required to lift the leg is lost.

In a given case, perhaps as good a criterion as any other in estimating the probable outcome and probabilities of short or long ligamentous union is the ability, or otherwise, to bring the fractured surfaces in contact. If this can be done without much pressure with the fingers, the prognosis as regards close fibrous union is infinitely better than in the cases where this is impossible. Where excessive effusion or hæmorrhage into the knee-joint occurs, the difficulties usually met with in approximating the fragments are increased, and the prognosis will vary accordingly. Those cases in which the joint does not become distended, and the fragments are not separated, are the most favorable as regards close union; and per contra, those cases will be unfavorable in proportion to the extent and duration of the separation of the fragments as dependent upon the amount and duration of the effusion.

In cases in which bony union has been obtained, nothing save organic change in the knee-joint producing anchylosis, or injury to the quadriceps extensor cruris muscles is likely to prevent a complete and perfect restoration of the usefulness of the limb.

Complications, etc.—One of the most serious complications of fracture of the patella is the rupture of a vessel, usually one of the articular arteries, and the occurrence of a hæmarthrosis. The following case, previously published,[28] will serve to illustrate the class of cases under consideration.

Mrs. R. M., aged fifty-eight, fell while descending a flight of stairs, and suffered a transverse fracture of the patella. In a short time her knee-joint became very much distended with fluid. Under cold applications, evaporating lotions, and compression, the hæmorrhage into the joint which had been diagnosed was arrested. At the end of the seventh day it was deemed safe to apply a plaster-of-Paris splint. Three days afterward, after gradually increasing sense of fulness in the joint, intolerable pains came on, necessitating immediate removal of the dressings. The joint was found to be again distended, and an attempt to aspirate was made, which failed. Cold compresses again applied. On the fifteenth day following the receipt of the injury, the pulse and temperature rose, the tension in the joint increased, and chilly sensations were complained of, with considerable pain along the anterior surface of the thigh. After making another attempt to aspirate, it was determined to open the joint by incision, and seek for and ligate the bleeding vessel. This was done with the strictest Listerian precautions, by a longitudinal incision in the middle of the anterior surface of the knee-joint. Half a pint of coagulated blood was turned out of the cavity of the joint. The source of the hæmorrhage was found to be a *per saltum* stream from the internal articular artery. This vessel had been torn across by the giving way of the accessory band of ligamentous tissue extending from the vastus internus muscle to the head of the tibia. This band had been ruptured, not on a line with the fracture of the patella, which was almost exactly on a line with the centre of the bone, but about one and a half centimetre lower down. A transverse incision was made, extending toward the inner side of the joint, and the bleeding vessel secured by a catgut ligature.

Another serious complication is the occurrence of injury to the periosteum, particularly in cases of compound fracture, leading to necrosis of one or both fragments, and the necessity of removal of the same. A case of this kind, already quoted,[15] ultimately recovered, with a very satisfactory restoration of function of the quadriceps extensor muscle. Koenig[29] is credited with a similar case.

When the manner in which transverse fractures occur is borne in mind, it is not a matter of surprise that more or less injury to the quadriceps extensor cruris muscle itself should occur, by the tearing of its fibres, blood-vessels, nerves, etc.; the damage done may be sufficient to cause its deterioration, or notable atrophy may follow.

The *Treatment* of fractures of the patella constitutes one of the most interesting subjects in the whole domain of practical surgery. The treatment of this class of injuries will undoubtedly be successful in direct proportion as it is directed toward the attainment of the following objects: 1. The removal of the effusion poured into the joint. 2. The removal of any substance lying between the fragments, preventing osseous union where the latter is deemed desirable. 3. The approximation of the surfaces of the fractured bone, and maintaining them in this position until union of the fragments, either by bone or ligament, is assured.

In the carrying out of the first of these indications, namely, the removal of the effusion poured out in the joint, the object is to be accomplished, first, by placing the limb in a position of perfect rest, and the application of evaporating lotions, etc.; and second, by aspirating or opening the joints. It is a matter of common experience, however, that this effusion is not of sufficient duration to prevent union by ligament, at least, other things being equal. Should it persist, and in sufficient quantity to over-distend the joint, and thus seriously threaten to invalidate the efforts to maintain the fragments in their proper relations to each other, aspiration of the joint may be practised. This may be done with advantage by the method suggested by Barwell in aspiration of the ankle-joint, namely, by first applying a Martin elastic bandage to the joint, leaving a small portion of the surface exposed, at which the aspirator needle, or trocar and cannula, can be passed into the joint. The most convenient place for the puncture will be found to be slightly above the level of the internal condyle, and on a line with the middle of the patella, when the latter is in its normal relation to the anterior surface of the knee-joint. It is needless to say that even this little operation should be conducted with the strictest antiseptic precautions, for any infection carried into a joint in the condition of the knee-joint following fracture of the patella, may set up a suppurative inflammation; thus imperilling both life and limb of the patient. In the hands of one versed in the modern methods of wound treatment by the use of antiseptics, the operation of aspiration of the joint, or even that of puncture with trocar and cannula, after the manner of Schede, of Hamburg, and irrigation of the joint cavity, is fraught, practically, with no danger.

The carrying out of the second indication, namely, the removal by open incision of any interposing soft tissues from between the fragments, has been already alluded to in connection with the general consideration of transverse fracture of this bone. In the opinion of the writer, the whole question of obtaining osseous union on the one hand, or a fibrous connecting band on the other, be-

tween the fragments in this variety of fracture, turns upon this as a pivotal point. Except in the very rare instances where the almost phenomenal coincidence of a fracture of the transverse variety occurs in connection with the escape of the prepatellar aponeurotic structures from damage, and in which the fragments can be brought together with comparative ease by directly applied mechanical force, such as Malgaigne's hooks, it may be stated, as a general proposition, that union by bone is exceedingly rare. In other words, where it is considered desirable to obtain bony union beyond peradventure of a doubt (and no other result can be said to be a perfect one when this is obtainable), measures must be put in force looking to the removal of the interposed soft tissue, and the bringing together and then securely holding the fractured surfaces. This can be done in a satisfactory manner only by means of an open incision into the joint and exposing the bony surfaces; where it is found impossible to disentangle the shreds of torn fibrous tissue from the rough surfaces and projecting spiculæ of bone, it is proper to remove a thin slice of bone from the opposing surfaces with the saw. However accurately the fragments may be adjusted, or securely held after adjustment, without opening the joint and exposing the fragments, there will be an insuperable barrier to bony union so long as the firm and complete contact of the bony surfaces is prevented. This leads at once to the consideration of the propriety of opening the joint, removing any loose and interposing fibrous tissue from between the fragments, and bringing the latter together and retaining the same in position by means of the wire suture. This subject is one that has created widespread interest and discussion of late years. There cannot be two opinions as to the enormously great advantage which one patient, who has obtained osseous union following transverse fracture of the patella, has over one who has simply a ligamentous connection of variable length and stability between the upper and lower fragments. Equally indisputable is the fact that bony union is obtainable with comparative ease in the hands of surgeons who possess sufficient boldness to carry into effect the measures necessary to such a result. The indications for osseous union are therefore obvious, and the means of obtaining the same always at hand. Then the question is asked, why not take advantage of our opportunities, and give the patient the benefit of bony union in all cases? In answer to this question it may be said that, while all surgeons admit the great advantages of obtaining direct bony union, yet all are not agreed, in view of the fact that relatively good use of the limb is obtainable under a plan of treatment which involves no danger to life and limb, that the advantages gained in cases of osseous union are sufficiently great to offset the increased risk which the patient runs in obtaining the benefit of such a result.

We will first confine our remarks to the subject of the propriety of applying the wire suture to cases of recent transverse fracture of the patella. Inasmuch as great reliance has been, and is now, placed upon the use of antiseptics in order to ward off many, if not all, of the dangers of this operation and its results, it is well to weigh with great care the figures as furnished by more recent writers. It is the opinion of the writer, however, that but very little reliance can be placed upon the use alone, in this matter, of figures. The whole question will be determined upon the strictness with which individual surgeons follow antiseptic precautions in the treatment of wounds. A half-hearted antisepsis will generally leave many loopholes for error; and yet it will be announced that the operation, or series of operations, were done antiseptically. It is a well-known fact that the best results are reported by surgeons well versed in antiseptic methods, and enthusiastic supporters of the merits of the principle underlying the system.

Professor Dennis,[30] of New York, has tabulated 186 cases of metallic suture of fractured patella. Of this number 75 are classified as being good as regards result; 35 as being fair, and 24 as poor. Eleven deaths are reported in this series; 4 suffered amputation, and 34 are stated to have had the recovery complicated with suppuration. Fourteen of those classed as being poor were placed in this catalogue by reason of complete anchylosis, while 17 of the cases denominated as fair had partial anchylosis.

It is only fair to state that these figures are collected from a variety of sources, and do not by any means represent the best work of those surgeons who practise aseptic or antiseptic surgery. In fact, the boldness which impels a surgeon to open the knee-joint and wire together the fragments of a fractured patella is not always born of faith in, or knowledge of, the antiseptic methods which alone render such a procedure safe or justifiable. It not infrequently happens that these precautions are insufficient or even puerile, and disaster naturally follows the attempt. Brunner[31] reports 45 cases, in only 18 of which the operators pursued a strictly antiseptic course. In 8 cases of this series the purulent inflammation assumed a dangerous character, and 2 of these required amputation at the thigh, one of these latter ending fatally.

It is highly probable that if the causes of untoward results following this operative procedure were to be expressed in one word, that word would be sepsis. This, in the opinion of the majority of surgeons at the present day, is a preventable condition.

In view of the facts herewith presented, it would be proper for each surgeon to determine, in a given case, whether or not he had achieved sufficient knowledge of, or has sufficient faith in, the power of antiseptic or germicidal agents to prevent septic infection of the wound which he is about to make. Certain it is, that if any of these evil consequences following in the train of suppuration occurs, it is to be traced to the want of sufficient care on the part of the operator or his assistants. The responsibility, therefore, of the operation should not be undertaken lightly, but once undertaken, it should be followed out with the confidence born of firm faith in, and proper knowledge of, the requisites to success, together with a careful application of the same. Then this, as well as many of the other operations formerly placed upon the list of those unjustifiable because of undue risk to life involved in their performance, will be found, if not absolutely dangerless, at least to have had its mortality reduced to a point where it will no longer be a source of alarm to the profession and laity alike.

It has been the lot of the writer to open the knee-joint for one purpose or another a number of times, and the impunity with which this can be done when antisepsis has been observed, has been a matter of surprise and gratification. Indeed, in some instances the joint has been exposed an hour or more, and handled with not over-gentleness for the time being. Yet the patients have recovered, notwithstanding rough and prolonged manipulation of the tissue composing the articulation, without suppuration or other unpleasant sequence. More than this, there has been an absence of that adhesive inflammation which sometimes leads to such unpleasant after-effects when efforts are made to promote the healthy movements of the joint. To one in the habit of witnessing such instances of the wonderful improvements wrought in operative surgery by the introduction of antiseptic methods, it seems by no means a difficult or dangerous operation to open the knee-joint and place the fragments of a fracture of the patella under the best possible conditions for firm bony union. The operation, in the hands of skilful and competent surgeons, is destined to become divested of all danger to life as well as to limb. As an immediate plan of treatment it will, without a doubt, entirely supplant in time the uncertain and tedious means at the disposal of our forefathers, and in vogue to a great extent at the present day.

After what has been said as to the justifiability of suturing the patella immediately after a simple fracture, it would be superfluous to advance any argument in favor of treating in like manner a compound fracture of this bone. Here the indications are altogether in favor of immediate disinfection of the wound, and restoration to their normal condition, as far as possible, of the fragments.

The question of attempting the restoration of the functions of a limb lost through fracture of the patella, by opening the joint, clearing the parts, and bringing the fragments into apposition, must rest upon the decision as to whether the distance between the fragments is sufficient to account for the disability, and the success of measures of treatment to be alluded to further on. If the distance between the fragments is considerable and increasing, if the patient is a working-man, and particularly a young man, and if the quadriceps extensor cruris is not atrophied or otherwise in an abnormal condition, then it is justifiable—may, it may be said that it is demanded—with the full consent of the patient, that the operation be done.

The technique of the operation is very simple. Either a longitudinal or a transverse incision may be made of sufficient extent to expose the anterior surface of the bone. The parts should be well retracted and any soft structure intervening between the fragments should be dissected away. Should difficulty be experienced in disentangling the shreds of torn and stretched aponeurotic tissue from the sharp spicula of bone, a thin slice may be taken from the rough opposing surfaces. Each fragment is to be now drilled, and the method of performing this part of the operation is of some importance. The object is to secure as firm a hold as possible upon each fragment, and yet not perforate the cartilage covering the posterior or articular surface of the patella. This is accomplished by entering the drill in the median line of the bone as far away from the edge of the fractured surface as possible, perforating the bone in a diagonal direction, upward and backward, in the case of the lower fragment, and downward and backward in the case of the upper; the point of the drill is caused to emerge at the juncture of the cartilage with the fractured surface. A small cannula, such as is used for tapping hydrocele, is then passed through the perforation made with the drill, for the purpose of facilitating the passage of the wire; with this *in situ* no difficulty will be experienced in passing the wire. The wire should be of silver, annealed, and of a size sufficient to bear considerable strain. The fragments may then be brought together; and should this be not easily accomplished, section of the quadriceps muscle, just above its insertion into the patella, by means of a row of V-shaped incisions, after the manner recommended by Macewen, may be made.[32] These cuneiform incisions form gaps in the muscle, which, when the latter is put upon the stretch, are obliterated. In this manner the muscle at this point is lengthened without materially weakening it, as would be the case if the incision were made in a transverse manner.

Fig. 2765.—Method of winding Wire around Dressing-forceps in removing it from the Patella. (After Macewen.)

The best method of disposing of the ends of the wire after twisting them together, and then coaptating the fragments, has been the subject of some discussion. Lister originally advised that the ends be bent at a sharp angle, and hammered down upon the face of the patella. The writer suggested,[33] a number of years ago, as a means of disposing of the twisted wire after wire suture of bone, that it be reflected upon itself in such a manner as to be buried between the opposing surfaces of bone.

Macewen suggests, and I have had occasion to follow this practice with advantage, that the wire be twisted and left projecting between the edges of the incision, when it can be readily removed, at the end of six weeks, by first straightening the wire, cutting one end below the twist, and then grasping the other end between the heads of a pair of dressing-forceps, and withdrawing it by winding the wire around the forceps (Fig. 2765). In this manner all jerking movements, and consequent danger of breaking the wire, are avoided.

Drainage may be effected by placing two rubber drains at the side of the lateral ligaments. The bone drains of Neuber, or the chicken-bone tubes of Macewen are preferred by some.

Absorbent and antiseptic dressings, and the application of a well-padded back splint, complete the dressing.

The indications for a removal and renewal of the dressings consist in pain, elevation of temperature above 100° Fahr., or the appearance of discharge from the dressings. The redressing of the operation-wound should be done with the same rigid antiseptic precautions taken in the first instance. The drains, if of rubber, may be removed anywhere from the fourth to the tenth day. At the end of six weeks the wire should be withdrawn and a final dressing applied. If all goes well, it will be found that the entire wound, except where the wire emerges, will be healed. The tract occupied by the wire will be very small, and, under a small pad of paper-wool, or other antiseptic dressing, will close in a few hours.

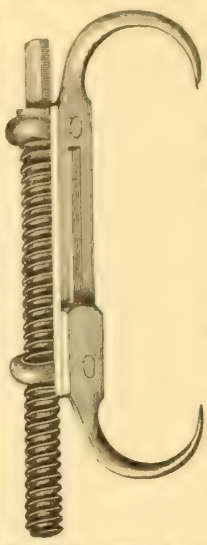

Fig. 2766.—Levis's Modification of Malgaigne's Hooks. (After Morton and Roberts.)

In cases in which it is deemed needless to inflict the additional traumatism incident to opening the joint, and union by ligament or fibrous tissue is only hoped for, the closest possible approximation of the fragments should be procured. This may be best accomplished by the use of Levis's[34] modification of Malgaigne's hooks, in cases where the distance between the fragments is considerable, and where difficulty exists in keeping the same near to, or touching, each other. Levis's modification of the hooks consists of a separation of the set into two parts which act independently of each other. By this change the bone is held more firmly and accurately. It is difficult, on account of the irregular surfaces of the patella, to hold the fragments in position with both pairs of hooks held rigidly together, as originally designed by Malgaigne. They act "like a four-legged stool upon an uneven floor." One of the pairs, as modified by Levis, is shown in Fig. 2766, and the method of application in Fig. 2767. The hooks should never be applied while inflammation resulting from the injury is present; it is likewise considered advisable to give an anæsthetic at the time of their application.

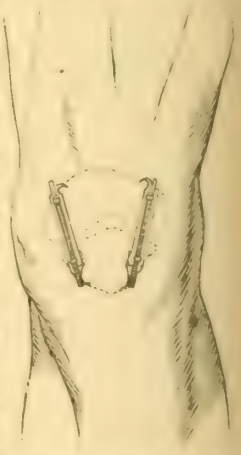

Fig. 2767.—Levis's Hooks Applied. (After Morton and Roberts.)

Inasmuch as in the application of the hooks four punctures of the integument, of greater or less depth, are made, through which points of puncture infection of the underlying tissues may occur, it is only a reasonable precaution to take, to thoroughly disinfect the whole field, and apply antiseptic dressings over the hooks.

The number of apparatuses and devices for the treatment of fracture of the patella is legion, being equalled in this respect only by those designed for the treatment of fracture of the clavicle. A volume could be filled with descriptions of the methods employed, from the expectant plan of Mr. Pridgen Teale, which consists essentially in applying no dressings beyond a simple evaporating lotion and a pillow or sand-bag support, with the patient lying upon his back, to the ingenious and elaborate apparatus of Dr. J. H. Hobart Burge,[35] consisting of a padded posterior splint and a series of cords and pulleys designed to approximate the

fragments by the use of what he terms the "*axis in peritrochis.*"

The plan adopted by the writer, of late years, in cases in which operative interference is declined or contraindicated, and which he prefers above all others of non-operative character, consists in applying at once a plaster-of-Paris or some other form of fixed dressing, from just above the malleoli to a point in the thigh as high up as possible. This is strengthened by having incorporated in its substance, at the sides, several thicknesses of the fine-wire gauze or metallic cloth commonly used for mosquito-bar material. After a space of time varying from twelve to twenty-four hours, a fenestrum is cut at the site of the anterior portion of the knee-joint sufficiently large to expose the parts well. Two tightly rolled bandages are then placed, the one above the upper, and the other below the lower, fragment. Strips of adhesive plaster are now placed so as to embrace these rollers, and through them to firmly fix the fragments and at the same time force them toward each other. The plaster which holds the lower fragment in position will embrace the plaster-of-Paris splint upon a somewhat higher level than it occupies at the place where it crosses the roll or pad. So, likewise, the strip which secures the upper fragment will tend to drag the same downward, by embracing the splint and crossing the site of the popliteal space at a lower point than the level of the roller which it secures. The attempt should never be made to compel the immediate coaptation of the fragments; it is very unlikely to succeed, and will occasion an amount of discomfort on the part of the patient dangerous to the surgeon's reputation, if nothing more. It is better to readjust the strapping occasionally as it becomes loose. In this way it will be found that what at first seemed a very wide gap will become gradually lessened as the effusion in the joint subsides.

The question of elevating the limb after applying the retentive apparatus may be discussed here. I have seen patients made exceedingly, and to my mind unnecessarily, uncomfortable by attempts to aid the fragments in coming together. There can be no doubt as to the shortening of the rectus muscle by approximating its origin and insertion, and also that this can be attained by elevating the limb. Those who advocate this method base their opinion of its usefulness upon the assumption that the muscle is in a state of constant contraction, and that to this is due the separation of the fragments. This, as has been shown by Mr. Jonathan Hutchinson, is an error. If the muscle is left entirely to itself, it will soon cease to contract, and measures directed toward lessening the effusion in the joint, such as aspiration, etc., are followed by greater ease of approximation than existed previously. It is even possible that elevation of the limb, by placing it in a constrained position, may lead to irregular and vicious contractions of the muscles when none existed before. By carefully watching the limb and dusting lycopodium powder or powdered talc underneath the rollers, where the skin, in a delicate person, may become somewhat chafed, and packing loose cotton around the edge of the fenestrum as the swelling subsides and the casing becomes loose, in favorable cases approximation of the fragments may be secured to the extent of obtaining, as a final result, relatively short ligamentous union and a comparatively useful limb.

In the class of cases mentioned by Von Bergmann, in which disability following an otherwise good result is due to atrophy of the quadriceps extensor muscle, massage of the muscle may be practised. Tilaine[36] even proposes to treat cases of fracture of the patella primarily by massage of the muscle combined with what is practically an expectant method. It is probable that quite as little, if not less, disability would result from this plan of treatment as that which ordinarily follows prolonged confinement of the patient to bed, with cumbrous splints or other so-called retentive apparatus tightly bandaged to the limb. By Tilaine's method patients are encouraged to walk about after the first week; in six cases, according to his own statement, the patients could walk about very well in fourteen days. Of course, nothing but ligamentous union, and that, too, of considerable length, is to be expected from this method.

In a case coming under the notice of the writer a number of years ago, it became imperatively necessary for the patient to get about at once. A posterior splint of light hoop-iron was shaped to the limb, and held in place by straps and buckles. Rollers, so placed as to secure the fragments in as favorable position as possible, were held in place by adhesive plaster. With this apparatus in place, the patient, a milk-dealer, continued to serve his customers regularly without the loss of a single day's delay in his business. The splint was discarded in about five weeks, and the result was as good as that which follows any non-operative method of treatment.

Dislocation of the Patella.—It is customary for writers, following Malgaigne, to describe three varieties of dislocations of the patella, namely, outward, inward, and vertical luxations. The last variety of luxation has been deemed to be by far the least frequent, but a number of cases of this accident have been reported, within the last decade, which would seem to indicate that this variety of displacement is not so rare as was formerly supposed.

In vertical luxation of the patella, either one of its lateral borders may be dislocated into the saddle-like cavity occupying the median line of the femur. This happens more frequently in the case of the internal border than the external. As a result of this edgewise displacement, the articulating or posterior surface of the patella is turned either externally or internally.

Highly complicated mechanical influences are probably the cause of these dislocations. The theory that contractions of isolated portions of the group of muscles which go to make up the quadriceps extensor cruris, such, for instance, as the vastus internus or externus, seems to be scarcely admissible. The vertical position of the displaced bone is maintained by the support furnished it in its abnormal position by the inner lateral facet of the articulating surface of the patella.

The joint-capsule is torn, as a natural consequence of this luxation, as far as it is attached to the patella, and the fact of this laceration existing renders the reduction of the dislocation comparatively easy. Cases are recorded, however, in which attempts at reduction were not followed by success. A forcible flexion of the limb at the knee-joint seems to afford a ready method of reduction.

Of the displacements laterally upon the surface of the condyles of the femur, those upon the outer surface of the external condyle outnumber those upon the inner surface of the inner condyle ten to one, according to Streubel. The earliest recorded observations of this luxation note the greater frequency of its occurrence upon the outer surface of the external condyle. It was thought that the limitation of the saddle-like cavity between the condyles, by its relatively higher border, does not favor the displacement in this direction so much as in the direction of the outer and lower border of the joint-surface. Undoubtedly some significance should be attached to this anatomical peculiarity in considering the etiology of this variety of luxation of the patella.

The previous existence of genu valgum predisposes to the occurrence of the most commonly observed form of luxation of the patella. In this deformity, as shown by Hueter,[37] there sometimes exists a deep furrow upon the external condyle. When the knee is bent, the greater portion of its posterior surface rests upon the external condyle and upon the inter-condyloid space. It is only the inner longitudinal facet which touches the inner border of the articular surface of the internal condyle. In these cases, the knee being strongly flexed, sudden extension may implant the prominence of the patella lying between its longitudinal facets into this groove in the external condyle; whereupon the quadriceps extensor cruris muscle will, upon contracting, pull the patella over the furrow and beyond the outer border of the articular surface, upon the outer side of the external condyle. The capsule will be but moderately torn in the luxation occurring under these circumstances. The more marked

the deformity of genu valgum the more readily will the displacement occur. The depth of the furrow governs to a great extent the predisposition to luxation in this class of cases. In a very marked case of genu valgum but a slight rotation would be required, other things being equal, to produce a luxation.

Clinical facts point to the probable occurrence of outward lateral dislocation of the patella, under circumstances analogous to genu valgum. For instance, cavalry soldiers are prone to this form of displacement, when riding through an enemy's lines, or practising evolutions similar in character. Here the knee is strongly flexed, with the foot resting in the stirrup, and the thigh hugging the saddle. The lateral aspect of the joint comes in violent contact with the latter, and the outer facet of the posterior surface of the patella, more obtuse in direction, is forced upon the obliquely inclined plane which marks the anterior articulating surface of the outer condyle, until the vertical ridge between the patella facets slips beyond the summit of the condyle, where it is firmly held by the vigorous contractions of the extensor of the leg.

It is more than probable, therefore, that the commonest form of luxation, the outward variety, is brought about when the joint is in the act of extension, having been previously flexed.

The diagnosis of luxations of the patella is accomplished without the slightest difficulty. Simple inspection and palpation will reveal at once the nature of the injury.

In most instances, the reduction of these dislocations is attended with no difficulty. The patella may be pushed or elevated over the border of the articular surface of the outer condyle, and the bone will at once resume its normal position. It sometimes occurs, exceptionally however, that the capsule is but slightly torn, and the vertical ridge of the patellar articulating surface is held firmly down by the strong joint-capsule, and resists all efforts at reduction. Malgaigne proposed, in such a case, to fasten a peg into the patella, and, with the aid of this acting as a lever, elevate, and at the same time, by a "prying" movement, force the bone from its abnormal position. A common carpenter's gimlet may be brought into use in the same manner.

It is well to bear in mind the manner in which the luxation, in the great majority of cases, occurs, and to attempt the reduction according to physiological rules. This, in the class of cases under consideration, would lead to a forcible flexion of the knee, giving at the same time to the patella such a twist upon its long axis as to cause this to slip into the inter-condyloid fossa. The rectus femoris may be relaxed somewhat by flexing the thigh upon the abdomen.

Upward or downward displacements of the patella are caused, in the case of the former, by rupture of the ligamentum patellæ, and in that of the latter by its detachment from the quadriceps by a laceration of this muscle.

Whatever injury may occur to the knee-joint itself in connection with a luxation of the patella is to be treated according to the indications present. It would be well, in all cases, to apply evaporating lotions and enjoin rest of the joint until all danger of inflammatory action had passed.

Other Injuries of the Patella.—Mechanics and others are the subjects, occasionally, of incised wounds upon the anterior surface of the knee-joint, involving the patella. The blow may be of a glancing character, as with an axe or adze, in which case a portion of the bone may be carried away; or there may be a direct incision into the substance of the bone, as related by Gamgee.[38]

The entire bone may be torn away, and yet the patient recover with a useful limb. An instance of this kind is recorded by Dr. Alexander, of Salem, Va.[39] The patient had his entire left patella torn away by a circular saw. The condyles of the femur also suffered somewhat. The soft parts were adjusted after removing some fragments of bone still adhering to portions of ligament; thorough cleanliness was observed, the parts being well washed with tepid water, and the wound was closed with sutures and adhesive plaster; the limb was then laid in a fracture-box. At the end of seven days the wound was examined, and found to be perfectly healed. Passive motion was made in the seventh week, and the patient recovered the use of the limb to a remarkable degree. The patella may be carried away by gunshot injury, with but trifling damage to the knee-joint. W. Ward[40] reports a case in which the full contents of a fowling piece at short range were received upon the side of the patella. The entire bone was carried away, and the cavity of the knee-joint opened. Conservative treatment was determined upon, and under a simple oil-and-lint dressing the wound finally closed; the limb ultimately became as useful as ever.

Rupture of the Ligamentum Patellæ.—This injury is of common occurrence. The rupture seems to be brought about by a sudden movement of falling forward, with the leg in a flexed position. In a case related by Chiene,[41] the patient in going down a ladder caught his right foot upon the last step and fell forward, his right leg bending under him. He walked into the hospital and upon examination the ligamentum patellæ could not be made out, and the power of extending the leg was lost.

Dr. Gould,[42] of Boston, relates the case of a man who, in attempting to reach a train in motion, ruptured the ligament of the right patella by his efforts in running. Here the accident seems to have been produced by muscular contraction.

Professor Sands,[43] of New York, quotes Maydl as being able to collect but sixty-five examples of this injury, and adds thirteen cases collected by himself from the records of Bellevue and other hospitals in the city of New York.

When the thickness and consequent strength of the ligamentum patellæ and its comparatively slight exposure to injury are considered, together with the mechanism of transverse fracture of the patella, the relative infrequency of this injury will be readily understood.

In all probability rupture of the ligamentum patellæ can be traced, in the majority of cases, to indirect violence, although Professor Sands calls attention to at least seven cases in which violence was done to the knee-joint directly. It should be borne in mind, however, as this surgeon remarks, that the fall upon the knee may have been the result, rather than the cause, of the rupture of the ligament. In all probability the extensor muscles are strongly contracted at the moment of the occurrence of the accident. In the majority of instances this injury occurs in the male sex, thus still further suggesting the probability that contraction of powerful muscular structures contributes, more than any other one factor, to the production of this lesion.

It occasionally happens that the rupture takes place on both sides simultaneously. One case of this kind is noted by Sands, and four others have been referred to—one by Hamilton, one by Gibson, and two by Shaw. Although it is difficult to understand why it should be so, yet it happens that in no less than three of the cases reported there had previously existed fracture of the patella on the same side. Fracture of the patella may, by lessening the patient's ability to maintain his equilibrium with ease and certainty, establish a predisposition to further injury in this region; the fibrous connecting band present after a fracture of the patella may, from its tough and unyielding character, be able to bear a greater strain than the patellar ligament itself. That this may occur is shown by the occasional occurrence of refracture of the patella, or, more properly, of a second fracture of this bone when the first fracture has united by a strong ligamentous union, and in cases where the bone is sound and uninjured.

The rupture is, as a rule, complete. In Professor Sands' thirteen cases only a single instance occurred in which the rupture was incomplete. Usually the rupture takes place at either one or the other of its extremities, rarely in the middle.

The diagnosis of rupture of the ligamentum patellæ is made with but little difficulty as a general thing. The symptoms are so well marked as to leave but slight doubt as to the nature of the injury. It will be found

upon examination that there is almost an entire absence of the ligamentum patellæ, and a gap, more or less distinct, is found to have taken its place. In addition to this there is the same inability to extend the leg present in transverse fracture of the bone itself, where the prepatellar structures are completely torn in addition to the injury to the bone.

The rupture of the ligament may extend into the joint by tearing across the lower reflection of its capsule. In such a case the joint becomes very painful and distended soon after the accident, but whether this is due to extravasation of blood or inflammatory effusion is not yet determined. The distention of the joint from this cause, however, is quite transient, subsiding in the course of eight or ten days.

In the treatment of this injury it has been customary to carefully follow the same general plan as in fracture of the patella; this consisting of elevation of the injured limb, cold applications to the joint, and the use of such means to promote extension and fixation of the joint which are considered appropriate in cases of fracture. In addition to these, compresses, straps, and bandages, having for their object the retaining in position of the ruptured ligament, have been considered useful. When the distention of the joint is considerable, some difficulty may be encountered in approximating the ruptured ends; but, as before stated, as a general rule this subsides, if it be but serous effusion, in a few days, before which it will be worse than useless to attempt to force down the upper end. Should the absorption of the effusion be delayed for any reason beyond ten days, the joint should be aspirated. One thing should be borne in mind in the class of cases in which considerable effusion exists—the early application of compresses and tight bandages, the latter with a view of hurrying the process of absorption, will cause an aggravation of the symptoms and compel a suspension of all treatment for a time. By the exercise of caution in this respect, and simply elevating the limb, treating the injury rather on the expectant plan than yielding to the impulse to crowd together the ruptured ends as soon as possible, the comfort of the patient will be greatly enhanced, and as good results obtained as by the more active procedures. In the course of six or eight weeks, even with simple elevation of the limb and the application of a plaster-of-Paris dressing, including the leg and thigh, the continuity of the ruptured parts is restored, and a fair amount of recovery of the function of the disabled limb is at once observed. This improves as time goes on, the knee gradually regaining its normal size and shape. Movements of the joint are soon carried on with but little pain or inconvenience, and the power of extension returns, although to a variable degree. This will be best promoted by massage of the quadriceps extensor muscle, by which means the atrophy incident to the prolonged inactivity of the muscles will be overcome. In a case treated by Weir in this manner, in St. Luke's Hospital, New York, in 1869, sixteen years afterward no difference could be made out between the patellar ligaments of the two sides, and the patient declared that the limb injured was quite as good as that of the opposite side.

On the other hand, however, the patella may remain permanently retracted in spite of every effort to maintain it in position, and this may occur to the extent of several inches. In such cases the impairment of function will be more decided, although to this rule there are many exceptions. It also happens that close approximation of the ruptured ends does not always insure restoration of function. This is in all probability due to some injury inflicted other than that to the ligament itself, such, for instance, as some permanent damage done to the quadriceps muscle, or interference with its nerve-supply and consequent atrophy; chronic inflammation of the knee-joint, or adhesions between the opposed surfaces of the synovial sac lying beneath the quadriceps. Here both flexion and extension are interfered with and the patient is seriously crippled.

In those instances in which no union takes place there will be a total loss of power to extend the limb, and the ability to walk without assistance will be entirely lost. It is more than likely that a greater number of these cases result in permanent impairment of function of the quadriceps than is generally supposed. In the cases in which failure of union takes place it has been the general practice to equip the patient with some form of apparatus designed to keep the knee-joint rigid, or to imitate the power of extension of the quadriceps extensor cruris muscle by the use of elastic force. Recently Professor Sands,[43] of New York, has succeeded in restoring to a useful condition a limb rendered useless by an ununited rupture of the ligamentum patellæ.

The patient had received a falling timber upon his right knee, while at sea, and was at once disabled thereby. Seven months later he applied to Professor Sands, wearing a posterior leathern splint, without the aid of which he was totally unable to walk. The ligament had been torn away close to its tibial attachment; the patella was drawn up about two inches. It could be moved readily from side to side, but could not be drawn downward to its normal position. The attachments of the quadriceps to its upper border could be readily made out, but all connection with the tibia had evidently been destroyed. A longitudinal incision about nine inches long, in the middle line, exposing the tubercle of the tibia, the patella, and the lower portion of the quadriceps, was made, the parts being freely exposed and the ends of the ligament freshened. Some dense fibrous tissue occupied the site of the normal attachment of the ligamentum patellæ to the tibia. This was also freshened and afforded a good, firm hold to the silver-wire sutures, by means of which, after making several incisions into the quadriceps muscle, the ligament was finally brought down to, and fastened in, its normal position. The patient did well, and Professor Sands exhibited him to the members of the New York Surgical Society, December 8, 1885, seven months after the operation, with the usefulness of the limb restored and many of its movements perfect. In cases in which the ordinary measures of treatment fail in bringing about union of the ruptured ligament there can be no question as to the propriety of performing Sands' operation for the restoration of the usefulness of the limb, provided a full and conscientious regard be paid to the necessities for a most rigid and thorough antisepsis.

Bursitis of the Prepatellar Bursæ.—The prepatellar bursa is occasionally traversed by partitions, more or less complete, dividing the bursa into two or more complete and independent sacs. These septa may become thickened, increased vascularity of their tissues takes place under the influence of inflammation or irritation, and rupture and effusion occur in the cavity or cavities of the bursa.

Acute bursitis of the prepatellar bursa is usually the result of an injury. The anterior aspect of the knee-joint becomes more or less tender and tense, and a fluctuating swelling makes its appearance. The skin assumes an erysipelatous hue. The pain is usually very severe, and may be of a lancinating character. More or less constitutional disturbance coexists. The redness may extend, in the course of a day or two, both upon the thigh and down the leg to the ankle-joint. Even gangrene, as the result of excessive inflammatory action, may occur. Œdema of the surrounding parts occurs, and this is usually an indication that suppuration has set in. The constitutional disturbance increases when this latter occurs. The limb becomes fixed in a slightly flexed position, and movements are exceedingly painful at times and always difficult.

If the case terminate by resolution the inflammatory symptoms quickly subside, only to recur if there be a gouty or rheumatic diathesis entering into the case as an etiological factor. Some thickening may be left, in any event, marking the site of the recent inflammation.

When the termination is by suppuration, the latter announces its presence by an aggravation of the acute symptoms. The integument covering the bursa becomes thin and shining, and unless measures be taken to evacuate the pus a spontaneous opening may occur. The

possibility of suppurating bursitis leading to caries of the patella has already been alluded to.

The only condition with which acute bursitis of the prepatellar bursæ is at all likely to become confounded is cellulitis of the thigh, extending downward over the anterior portion of the knee-joint. The fact that the swelling and redness began at the site of the bursa will usually suffice to prevent error in the differential diagnosis. Acute synovitis of the knee-joint could scarcely be suggested by the appearances presented by an acute bursitis in this region, yet the writer has known of at least one instance where this occurred. No excuse can exist for the commission of this error; the position of the patella itself, in its relation to the swelling, should settle the question at once. The history of a blow upon the anterior region of the knee-joint may not always be obtainable. It is not an uncommon matter for a period of twenty-four or even forty-eight hours to elapse from the reception of the blow until the onset of the symptoms. Again, the blow or other injury may be of so slight a character as to have escaped especial notice.

Subacute and chronic enlargements of this bursa, or "house-maid's knee" as it is commonly called, constitute an unsightly and inconvenient tumor over the patella, interfering greatly with progression. They occur most frequently in servant-maids, stone-masons, and others who are in the habit of kneeling more or less constantly. Over-exertion in walking may bring on this variety of the inflammation of the sac to a minor extent.

The swelling in "house-maid's knee" is soft and fluctuating, hemispherical in shape, and unaccompanied by enlargement of the veins or the presence of any marked changes in the overlying integument. Pain is very seldom a decided symptom, although tenderness upon pressure and considerable soreness in walking are usually present. In cases of very long standing the enlargement may extend beyond its usual size, that of a small orange, to the dimensions of a fetal head. This latter, however, is exceptional.

In recent cases the diagnosis can be readily made; the existence of a fluctuating swelling at the site of the bursa, and the relative position of the patella, will settle the diagnosis beyond a doubt. Thickening of the walls of the bursa, however, may, in old cases render the sense of fluctuation obscure, or prevent its appreciation altogether. The growth, in this latter instance, may simulate a solid tumor. True hygroma, or the hypersecretion due to simple irritation or congestion (a true dropsical condition of the sac), occurs but rarely, and need scarcely be taken into account.

In the treatment of bursitis of the prepatellar bursa, attention should be paid to the variety of the disease under notice. In the acute form, local antiphlogistic measures—lead-and-opium wash, etc.—should be employed. If there be a suspicion of a gouty or rheumatic causation, remedies appropriate to these should be exhibited. When the existence of pus becomes indubitable, and not before, a free incision to evacuate the same should be made. In some of the cases great general depression may exist, in which case iron and quinine should be given, and other supporting and stimulating treatment instituted. The limb should be placed in an easy position upon a pillow and somewhat elevated. After incision, antiseptic irrigation several times daily, and the application of an absorbent dressing, having some antiseptic agent incorporated in its meshes, will serve a better purpose than the employment of poultices.

In the subacute or chronic variety of the affection, blistering, the application of tincture of iodine, or other measures of this character, are very seldom of service. Aspiration of the fluid in cases where the walls are but moderately thickened, washing out the cavity with a solution of mercuric bichloride (1 to 1,000) or a solution of potassio-mercuric iodide (1 to 4,000), followed by the introduction through the cannula of a few strands of previously sterilized horse-hair as a drain, will, in the vast majority of cases, lead to a radical cure; antiseptic dressings should be applied after this little operation, and the limb kept at rest for a few days. Upon removal of the drain, say at the end of forty-eight hours, a second dressing should be applied. This method of treatment failing, incision and drainage, with perhaps excision of the sac should be practised. This latter treatment is the only applicable method of dealing with tumors in this region, the result of a solidification or fibroid degeneration of the interior of old bursæ.

A simple hygroma may be treated with blistering, tincture of iodine, etc.; this failing, aspiration and hyperdistention, by means of a two and one-half per cent. solution of carbolic acid, for the purpose of slightly stimulating its interior, will ordinarily bring the case to a satisfactory conclusion. *George R. Fowler.*

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PATENTS. The general willingness of physicians and surgeons to permit free use of their inventions and improvements diminishes the importance to them of any detailed account of the patent laws; but a general sketch of that subject will be useful. Patents are granted under act of Congress, not under State laws. The business connected with them is conducted at Washington in the Patent Office, which is a branch of the Department of the Interior. Suits involving the validity of patents are brought in United States courts, though suits to enforce contracts belong to State courts, even if involving patents. A patent-right is not objectionable as a monopoly, but is of the nature of a contract between the Government and the inventor that the former will guarantee exclusive control of the invention for a limited term of years, and that the latter, in return, will disclose the invention so fully that the public shall have the benefit of the invention after expiration of the term. Thus, whoever discovers a useful prescription or surgical instrument may keep the knowledge of it to himself, and, if he can, may confine the use of it to his own practice indefinitely. Or he may, by obtaining a patent, secure a legal right, capable of enforcement in the courts, which, however, will last only seventeen years. If the inventor adopts the latter course, he must file in the Patent Office a

written description of his invention and a precise statement of what he claims. He may properly conduct this correspondence himself, by addressing directly the "Commissioner of Patents," Washington, D. C.; and a pamphlet of full instructions for such correspondence is furnished gratuitously to all who ask for it. But the proceedings are complex, and the preparation of the "specification," as the description and claim taken together are usually called, requires great care and accuracy. Hence the employment of a patent "agent," or "solicitor," is almost universal.

The important question is, What may be patented? The law embraces "any new and useful art, machine, manufacture, or composition of matter." The invention must be both "new" and "useful." That is to say, the applicant must be able to make oath that he himself devised it, though he may have received some aid; and it must serve some beneficial purpose, though the benefit may be very slight. The word "machine," as understood in law, embraces all forms of surgical apparatus and instruments, and "composition of matter" includes mixtures of drugs. Whether novel and complex operations in surgery can be patented, as coming within the word "art," is not easy to say positively. In the ordinary application of the patent law a "process" is considered patentable; but there has never been any extension of this doctrine in the direction of medicine and surgery. The simple discovery of the medical properties of drugs, though previously unknown and highly useful, is not within the law. Thus, a patent was denied to the discoverer of the anæsthetic property of chloroform, ether, etc. The courts said that he had merely ascertained a fact of nature, a property of certain substances; he had not devised any new thing. In short, the possible applications of the patent law are limited to novel appliances and instruments for surgery and novel prescriptions or mixtures of drugs put up for use.

A law passed in 1874 abrogated the practice of copyrighting labels for patent medicines or other articles of manufacture, but provided for registering such labels in the Patent Office; and the "Trade-Mark Laws," so called, of the States give some means of securing the name of an established and popular remedy against imitation by competitors. It remains to be said that, in many foreign countries, pharmaceutical preparations, compositions of drugs, remedies, medicines, etc., are expressly excluded from the benefit of the patent laws.

Benjamin Vaughan Abbott.

PAU. The city of Pau, chief town of the Department of the Basses-Pyrénées, France, stands upon the north or right bank of the river called the Gave de Pau, at the height of 130 feet above the river-bed, and 620 feet above sea-level. The latitude of Pau is 43° 17′ N.; its longitude is 0° 23′ W. The population of the town is about twenty-five thousand. Its situation, on the edge of a plateau immediately above the river-bed, and the location, at the brink, as it were, of this plateau, of the old castle with its terrace, of the Place Royale, the Boulevard du Midi, and the Parc (containing thirty acres of ground and beautifully planted with shade-trees), render the town a decidedly picturesque place in appearance, while the view of the Pyrenees Mountains, which may be had from all the points just mentioned, is remarkably fine, and is said by Murray to be similar to, although inferior to, the famous distant view of the Alps which is obtained from the platform at Berne.

The reputation of Pau as a winter health-resort is notoriously great, and its hotels are excellent, especially such as lie in that part of the city which is nearest the edge of the plateau, and from which the view just mentioned is obtained. This portion of the city, at least, is well drained; of the rest I cannot speak positively. The soil at Pau is sandy.

The mean temperature of each of the five months, November to March, is given by Dr. Julius Hann as follows: November, 47.84° F.; December, 43.34° F.; January, 42.26° F.; February, 44.42° F.; March, 48.20° F. I have no data at hand to illustrate either the extreme or the average daily maximum and minimum temperatures; but the average monthly range during the season in question is 36.5° F. (Hann's "Handbuch der Klimatologie"). Dr. Yeo tells us that "frost and snow and cold nights are not uncommon in winter;" and it is evident that the climate of Pau at this season cannot be pronounced a very warm one. In "Murray's Guide-book" we read that "though the climate is mild the variations in temperature are often sudden." On the other hand, Dr. A. Rotureau (in the "Dictionnaire Encyclopédique des Sciences Médicales"), although giving for the monthly means of November, December, and January figures which are lower than those of Dr. Hann, and although admitting that the temperature quite frequently falls below the freezing-point, nevertheless appears to regard the winter climate of Pau as one characterized rather by equability than by variability of temperature, and Dr. Weber tells us that the nycthemeral range of temperature seldom exceeds 16° F.

The mean annual rainfall is 42.7 inches, of which 11.3 inches falls in winter (Rotureau), and during the six months from November to April the average number of days on which rain falls is between eighty and ninety (Weber). As to the manner in which rain habitually falls, we are told by Dr. Rotureau that, although falls of rain are frequent, they are not usually of long duration, and commonly occur in the early part or toward the close of the day. The relative humidity of the atmosphere at Pau is considerable; according to Dr. Weber, it is on the average from eighty to eighty-five per cent. Dr. Hann's figures for the five months, November to March, derived from observations taken only twice a day (viz., at 7 A.M. and at 2 P.M.), are as follows: November, seventy-five per cent.; December, seventy-six per cent.; January, seventy-four per cent.; February, seventy-two per cent.; March, seventy per cent.

The leading characteristic in the climate of Pau, and the feature to which it largely, and no doubt deservedly, owes its popularity as a winter-resort, is the prevailing stillness of the atmosphere. The great chain of the Pyrenees Mountains, distant only fifteen or twenty miles, acts as a barrier to protect the region about Pau against southerly winds; while we are told by Dr. Yeo that "a series of plateaux rising behind the town" afford a good degree of protection from northerly winds. The west and the east are the quarters in which least protection against wind is afforded; but Dr. Rotureau claims that the hills known as the Coteaux de Jurançon and the trees of the Parc serve in some degree to break the force of the westerly winds, and that the easterly winds are modified in character by being obliged to pass over a district of relatively considerable elevation before reaching the town (sont mitigés par les hauteurs du terrain sur lequel ils doivent passer avant d'atteindre la ville). He also tells us that the east wind at Pau is a fair-weather wind and a dry one. The "mistral" of Provence and the Riviera does not exist at Pau, although the northwest wind is a bringer of cold and dry weather. The westerly wind is damp and warm. In Dr. Rotureau's article will be found other interesting facts concerning the winds of Pau, and concerning the comparative windlessness of its climate. Suffice it to say, in this place, that, while occasional wind-storms of considerable severity are there experienced, the climate is nevertheless one properly to be regarded as exceptionally free from winds.

Pau has unquestionably lost a part of its former great reputation as a winter sanatorium for pulmonary phthisis, and drier climates are more in vogue to-day for the treatment of that disease. Nevertheless, for some cases of this kind the climate of Pau may still be recommended. We have seen that the high-lying sanatoria of Europe do not suit all phthisical patients, and the same is true of other high-altitude resorts and of dry resorts not much elevated above sea-level. The cases of phthisis for whom the still atmosphere and rather moist air of Pau are especially suitable, according to Drs. Weber and Yeo, are such as suffer much from an especial irritability of the respiratory mucous membrane, with dry cough, and who possess the type of constitution known

as the "erethistic." Cases of chronic bronchitis and emphysema, and of spasmodic asthma, when occurring in persons possessing this erethistic, or easily excitable constitution, also do well at Pau.

The existence at Pau of an English club and other social facilities, the ease with which excursions may be made into the neighboring Pyrenees Mountains, and the proximity of the summer stations of Bagnères-de-Bigorre, Eaux Bonnes, Bagnères-de-Luchon, among the mountains, and of Biarritz, on the coast of the Bay of Biscay, are other points in favor of Pau.

Huntington Richards.

PEARSON SPRINGS. *Location,* Lake County, California.

Post Office, Lakeport, Lake County, Cal.

Access.—By Central Pacific (California Pacific & Northern Division) Railway to Calistoga; thence by regular line of stages to Lakeport, forty-eight miles; thence by conveyance to the springs, eleven miles.

Analysis.—None obtainable.

These springs, of which there are five, a soda, a sulphur, a sulphur and soda, and two gas springs, all cold, are situated in the Western part of California about one hundred and thirty miles north of San Francisco. The scenery is grand; the climate is fine, and there is good hunting and fishing. The hotel accommodates about sixty people.

Although no analysis is given, it is learned that the waters are purgative or aperient, respectively.

G. B. F.

PEDICULOSIS. Syn.: Lousiness, Phtheiriasis; Läusesucht (Ger.); Maladie pédiculaire (Fr.).

There are three different kinds of lice which prey upon the human body, and which produce the disease known as pediculosis. Although resembling each other in their general anatomy, they differ sufficiently to have received different names. They are designated according to the locality in which they are found, as follows: 1, Pediculus capitis, or head-louse; 2, P. vestimentorum, clothes- or body-louse; 3, P. pubis, pubic or crab-louse.

The *Pediculus capitis* is an animal 2 mm. (one line) in length, having an oval-shaped head with prominent eyes, and two five-jointed antennæ, one on each side. Running from the foremost part of the head is a jointless tube-shaped snout, which ends in two movable hooks. On each side of the thorax are three legs, covered with hair and armed with strong, sharp claws, which adhere to the outside of the last joint in such a way that the inside of the joint turns up into a hook, thereby enabling the animal to take a firmer hold. The abdomen, which is broader than the head and thorax, is marked by seven segments, and on the side are six stigmata or notches, which are connected with the trachea. Upon the back of the males there is a comparatively large, cuneiform penis, and two testicles (see Fig. 2768). The females are both larger and more numerous than the males. At the end of their abdomen is a depression or slit, in which are found the anus and vagina. The male is seized in the embraces of the female during copulation, the female climbing upon his back. The eggs, commonly called *nits* (see Fig. 2769, 1, 2, and 3), are fastened by a glutinous secretion, *a*, *a*, to the shaft of the hair near the scalp, either singly or in rows of twos or threes. The lowest egg is first deposited, then the others as the animal moves upward. They are hatched in from three to eight days, are full grown in from eighteen to twenty-one days, and are then able on their part to propagate. A full-grown female louse can lay fifty eggs in six days, and may have five thousand descendants in eight weeks.

Fig. 2768.—Head-louse, magnified.

The P. capitis is seldom found away from the scalp. In very filthy and neglected cases, however, their number may become so great that they are forced to leave the head in order to obtain nourishment.

The symptoms of P. capitis are intense itching, with traumatic eczema, following the ungovernable desire or necessity for scratching. When the hair is long and there has been much excoriation from abraded places, it becomes closely matted together, and we have what is called *plica polonica*, a condition which is principally found among the Polish Jews, who, even to this day, cultivate it with superstitious reverence because they believe it keeps off worse diseases and is a general harbinger of good luck.

Fig. 2769.—Hair with Nits of the Head-louse attached, magnified.

The diagnosis of P. capitis is easily made. The hair is gently raised, and a thorough search made for the nits. They appear as small whitish specks near the root of the hairs, to which they cling with remarkable tenacity. When these are seen, a still further search will reveal the lice themselves, which, when not filled with blood, are grayish-white in color.

The treatment consists in first killing the lice and nits, and subsequently applying remedies for the cure of the eczema. Many preparations have been used to destroy the animals, among which are mercury, infusions, decoctions and ointments of sabadilla, staphisagria, menispermum, rue, opium, angelica and laurel, saffron, pepper, sedum, lycopodium, pinguicula, tobacco, and the seeds of veratrum.

None of these, however, equals common petroleum, which may be applied either pure or in an ointment made with vaseline or lanolin. An energetic application of such a preparation should be made with a bristle-brush, and the head covered with an oiled-silk cap, to be left on twenty-four hours. When this is taken off, the head should be thoroughly washed in soap and warm water, and then, when the hair is dry, a soothing ointment is to be applied for the relief of the eczema. The nits, although killed by this treatment, still cling closely to the hairs, and cannot be removed by simple combing. A fine-tooth comb should be dipped, from time to time, in dilute acetic acid, and then run gently through the hair. The acid dissolves the envelopes sufficiently to allow of their easy removal.

The *Pediculus vestimentorum*, clothes- or body-louse, is the second variety found on man. It is larger than the head-louse, the head being longer and the abdomen more ample. The females (see Fig. 2770), like those of the former variety, are larger and more numerous than the males, and they also possess remarkable fecundity. The P. vestimentorum lives in the folds of the clothes, and remains only long enough upon the body to obtain its nourishment. The eggs are laid in the folds of the clothes also, and it is there that the young are hatched. Unless they are very plentiful, they may not be seen upon the skin itself when the clothes are removed, as at the slightest alarm they conceal themselves in the garments and are taken off with them. Hence the necessity of attending principally to the clothing of lousy people.

Fig. 2770.—Body-louse, magnified.

When body-lice are present there is an intense itching, which is accompanied by traumatic eczema, produced by

scratching. In cases of long standing, furuncles and abscesses, with an increased deposit of brown pigment, are seen. These lice also cause chronic urticaria.

The treatment is simple. The clothes should be thoroughly cleansed, either by washing or by exposing them to heat sufficiently intense to destroy the lice and nits. The patient should take a prolonged and very hot bath, while using plenty of tar or carbolic soap. Any accompanying disease, such as eczema, may be treated in the usual way afterward.

The *Pediculus pubis*, or crab-louse, is the third variety of human lice. It differs from the other two in shape and size (see Fig. 2771). It is most often found on the hair which covers the pubis, but it has been seen in the eyebrows, under the arms, and upon those places of the body which are most frequently covered with hair. It is not found, however, upon the scalp.

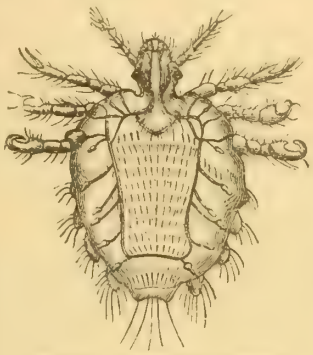

Fig. 2771.—Crab-louse, magnified.

These lice, like the head-lice, lay their eggs and fasten them to the hair-shaft by a glutinous envelope, and they multiply very rapidly. They are usually carried from one person to another during coitus, and their presence is soon suspected from the intense itching which their bite causes. They are seen without much difficulty, as they remain upon the skin and their nits are scattered about upon the hairs near them.

Besides the eczema, which is usually present, the inguinal glands may enlarge and even suppurate.

The treatment which is most effectual consists in the application of some one of the mercurial ointments. A small quantity of blue or gray ointment—unguentum hydrargyri—say from four to six grains, should be well rubbed into the skin with a bristle-brush. If one such application does not suffice, another may be made the following day. A spray of ether is also an excellent remedy. The ether should be sprayed into the roots of the hair, and a hot bath with tar soap must be taken immediately afterward.

The idea that there is a specific disease in which lice are produced by spontaneous generation within the fluids of the body has now been generally abandoned. It has been sufficiently well proven by Hebra and others that lice cannot live or generate in the fluids of the body, or in any place deprived of air.

Nevertheless, even since this apparent settling of the question, cases have been reported—one in 1865—in which lice were found living in an abscess, from which they scattered themselves in myriads after they were set free by an incision. Such cases, however, seem incredible from our present stand-point of knowledge.

A full history of the discussion on this subject is given in Ziemssen's "Handbook of Skin Diseases."

Robert B. Morison.

PELLAGRA. A complex disease, characterized by three classes of symptoms: 1. A squamous erythema, confined to those portions of the skin which are exposed to the action of heat and light. 2. A chronic inflammatory condition of the digestive passages, shown chiefly by obstinate diarrhœa. 3. A more or less severe lesion of the nervous system, leading at times to mental alienation and paralysis. These various symptoms are at first insignificant, and in a certain way periodic—they begin or recur in spring, and diminish or disappear in winter. Later they become persistent, more and more marked, and finally terminate fatally.

Pellagra has been known as a distinct disease for more than a hundred years; and numerous papers have been written upon the subject, chiefly by French and Italian authors. The disease is endemic in certain parts of Italy, France, and Spain, in the Danubian provinces of Austria, in Poland, Algeria, etc. Belgium, Germany, England, and America appear to enjoy an entire immunity.

Among the causes of pellagra may be mentioned hereditary predisposition, deficient alimentation, and bad hygiene. In those parts of Italy where pellagra is endemic, the poorer classes, especially the peasantry, suffer extreme privation as to lodging and food. During a considerable portion of the year their chief, if not their exclusive, food is a heavy, sour, indigestible bread made of flour from more or less spoiled grain. A similar diet prevails in most, if not all, the other countries where pellagra is endemic. That privation alone is not sufficient to give rise to pellagra is shown by the fact that in Ireland, where extreme privation has at times and in certain localities prevailed, pellagra is unknown. Some influence in the production of the erythematous symptoms must be attributed to exposure to the sun. Finally, mental alienation has been asserted as a cause of pellagra; but it is much more likely to be its effect.

A period of incubation has been supposed to precede the outbreak of pellagra, and there is reason to believe in the existence of a prodromal stage marked by diminution in strength and derangement of the digestive functions.

The cutaneous symptoms of pellagra are among the most constant and conspicuous. Erythema, a bright redness in the skin, of variable extent and accompanied by itching and burning sensations, is perceived. The seat of the eruption is on the backs of the hands and feet, sometimes the lateral aspects of the neck, the alæ nasi, the cheek-bones, the sternum, etc.—in fact, the parts exposed to the rays of the sun. The affected surface is smooth, rose-colored, never swollen, but is sometimes covered with papules and vesicles. Later the skin desquamates; the diseased surface presents a uniform red tint, sometimes compared to the cicatrix of a burn or to the skin of an onion.

This erythema usually shows itself in spring, during the months of March and April, decreases toward the end of summer, and disappears in the autumn, to reappear again on the approach of spring. During the interval between the attacks the affected skin is smoother, drier, and more sensitive than in the normal state. The following year the disease returns in the same portions of the skin as before, and at the same time of the year, showing, however, more decided symptoms than at first. The epidermis becomes hard, rugous, of a grayish or brownish color, and exfoliates in thick imbricated scales, so that the eruption takes on at the same time the appearances of erythema and of ichthyosis. Sometimes, particularly on the hands, a condition of *cutis anserina*, as in keratosis pilaris, is observed—a sort of permanent goose-flesh. Fissures occasionally form in the backs of the hands about the knuckles; the palms usually are not affected. The skin symptoms, appearing thus with the return of every spring, finally leave permanent changes behind.

Digestive disturbances are common in pellagra. Mild at first, they become more and more marked, and consist in dyspepsia, boulimia, cracking and fissuring of the lips, a fungous condition of the gums, a reddened, aphthous condition of the buccal mucous membrane, and a dry, cracked condition of the tongue; all these symptoms are shown in some cases, while ptyalism, a sensation of heat in the stomach and pharynx, difficulty of digestion, and pyrosis are also complained of. At first diarrhœa and constipation alternate, but later diarrhœa becomes predominant and the system is thereby much reduced.

The cerebro-spinal symptoms are shown, in particular, by alteration of sensibility, mobility, and intellect; vertigo; pain, or, rather, a sensation of heat along the spine; giddiness, apathy, an extreme repugnance to movement or work of any kind. Later the patient becomes feeble, his gait uncertain; the lower extremities are numb, and are the seat of formication and of a gradually increasing weakness, almost amounting to paralysis. At other times

the patients suffer from tremor and irregular movements, which give a peculiar and characteristic aspect to their gait. Hallucinations of sight and hearing are at times observed. The patients are obstinately silent or immobile; they speak slowly, show incoherence of ideas, a gloomy delirium, fixed ideas of despair, and even stupidity. In other words, every degree and many varieties of insanity are observed; occasionally there is even a suicidal impulse. A peculiar form of paralysis, that of the pharynx, has sometimes been observed.

The diagnosis of pellagra is usually easy, especially in the earlier and more typical stages. The erythema may be mistaken for erysipelas, but the course of erysipelas is so different that observation will soon show which disease is present. Chronic eczema erythematosum, or eczema rubrum, may at times resemble pellagra, but the peculiar characteristics of eczema—itching, vesiculation, etc.—will serve to differentiate the two affections.

In the absence of the characteristic erythema of pellagra, the diarrhœic symptoms may cause difficulty in diagnosis. But the peculiar condition of the tongue, lips, and gums, the heat along the œsophagus, the painful pyrosis which follows the ingestion of food, the apparently causeless and stubborn character of the diarrhœa, together with the endemic character of the disease, all aid in clearing up any doubt which may arise.

Pellagra varies greatly in its course and duration in different cases. Sometimes one symptom, sometimes another, ushers in the disease. The prognosis also varies greatly in different localities, apparently depending somewhat on the general condition of the locality as to healthfulness, and upon the hygienic conditions under which the patients live. In some parts of Italy the mortality is as high as one in twenty of the deaths from all causes.

In the treatment of pellagra, hygiene is of the utmost importance. Great attention has been paid to the subject of public health in relation to pellagra in Italy and Southern France. Improvements in drainage, and in the quality of the food, etc., are being introduced with good effect in various localities.

Among foods, milk holds the first place, and a milk-diet is most efficient in cases in which it can be thoroughly carried out. Sulphur-baths and sea-baths have been used also with good effect, this being due probably to their influence in improving the general health.

Direct medication, with a view to any specific effect upon the disease, has proved unavailing. Various forms of treatment are to be employed to meet the indications given by the different symptoms as they may arise.

(This article is chiefly based upon the excellent monograph of Henri Gintrac, in Jaccoud's "Nouveau Dic. de Méd. et de Chirurgie Pratiques," vol. xxvi.)

Arthur Van Harlingen.

PELLITORY (*Pyrethrum*, U. S. Ph.; *Pyrethri Radix*, Br. Ph.; *Pyrèthre officinal*, Codex Med.). The root of *Anacyclus Pyrethrum* D. C. (*Anthemis Pyrethrum* Linn.); Order, *Compositæ*. A pretty, chamomile-like, perennial herb, with prostrate stems and ascending branches, bearing doubly pinnatifid, dissected leaves, and large, handsome, terminal, radiate flower-heads. Involucre imbricated, rays in a single row, and pistillate, with broadly ligulate corollas (white above, pink below), disk-flowers yellow, perfect. Achenia flattened dorsally, slightly winged, wings ragged above, prolonged to a short auricle at each side. The root is rather fleshy, long, tapering, slightly branched, brown externally. Pellitory is a native of Algeria and other parts of Northern Africa, where it is also in cultivation, and of Arabia. It has been known as a medicine since the middle ages, its use having been learned from Arabia and India, where it has always been more valued than in Europe. It is, when dried, about as large as the little finger, and somewhat longer, tapering, nearly simple, annulate near the top, longitudinally wrinkled below, dark grayish-brown without, lighter within, brittle; fracture showing numerous resin-cells. Odor, none; taste, acrid, finally benumbing the mouth and producing a copious flow of saliva.

The active principle of Pellitory is contained in its abundant *resins* but has not been fully isolated. Buchheim's *Pyrethrin* does not appear to be a pure compound. Pellitory also contains *essential oil* and, like most composite roots, abundance of the inert *inulin*.

Action and Use.—It is one of the most potent of stimulant sialagogues, but the cases are very rare in which such a quality can be utilized. Its most general application is as a dental anæsthetic and counter irritant for toothache, etc., and it is the foundation of numerous "toothache drops." Since the general use of creasote, coca, and other things of that kind, and the more general practice of cleaning and filling dental cavities, Pyrethrum has fallen largely out of use.

There is an officinal Tincture (*Tinctura Pyrethri*, U. S. Ph.; $\frac{1}{10}$) which represents all its virtues; a drop in a carious tooth would be a good method of application. It is sometimes diluted for a gargle. Pellitory Root is sometimes chewed for toothache, but all this sort of medication is too unscientific to be recommended in the present state of dental knowledge.

Allied Plants.—In Germany the root of *Anacyclus officinarum* Hayne, cultivated in Southern Europe is used instead of the above. The constituents and action are the same. Several Persian and Caucasian species of the related genus *Pyrethrum* have recently come into universal use as insect-powders, on account of the remarkable stupefying power which a fine powder of their flowers, disseminated through the air, has over all kinds of insects. *P. carneum* D. C. (*Pyrèthre du Caucase*, Codex Med.) and *P. roseum* D. C. are the reputed sources of the Persian, and *P. cinerariæfolium* of the Dalmatian variety. The composition of these flowers is not fully made out, neither has their *modus operandi* upon the insects been explained; but they appear to contain a composite resin capable of being separated into two or three, in one of which the really active principle resides. *Spilanthes oleracea* (*Cresson de Para*, Codex Med.), in the same order, has also acrid-resinous constituents, and is an ingredient of odontalgic remedies. See Chamomile for the rest of the order.

Allied Drugs.—Besides the above, Aconitine, Creasote, Carbolic Acid, Cocaine, Oil of Cloves, Laudanum, hot water, and various other things are used for the relief of toothache. The active medicines should be carefully put *into* the sensitive cavity, if there is one, and not washed all over the mouth. *W. P. Bolles.*

PELLITORY, WALL (*Pariétaire*, Codex Med.); *Parietaria officinalis* Linn.; Order, *Urticaciæ*. A European weed growing on old walls and in by-places. It has some employment as a diuretic, but is comparatively inactive, and not entitled to be considered a medicine. It is said to contain a large proportion of nitrate of potassium.

Dose: Indefinite, in decoction. *W. P. B.*

PELVIC CELLULITIS. Anatomy.—Adequate knowledge of the inflammatory process, as it affects the pelvic connective tissue, presupposes clear and distinct notions of anatomical relations. The mode of union of the pelvic peritoneum with the organs it partly covers has been made the subject of numerous and exact studies, since the relations between connective tissue and the lymphatic system have begun to be understood. Three principal methods have been employed—dissections, plane sections of frozen or spirit-hardened pelves, and injection of air and various fluids into the subperitoneal space.

Luschka,[1] using the first method, found that beneath the peritoneal sac there is a stratum of connective tissue, more or less infiltrated with fat, which fills out the interstices between the peritoneum and the levator ani. The levator ani, as a diaphragm, divides the pelvis into an upper and a lower cavity. Accordingly, the entire pelvic space may be divided into three cavities—cavum pelvis peritoneale, cavum pelvis subperitoneale, cavum pelvis subcutaneum. Of these three divisions the cavum pelvis subperitoneale possesses great practical interest, as containing the larger portion of the pelvic connective tissue, numerous arteries, veins, lymphatics, and nerves.

To this space—between the peritoneum above, and the levator ani below—Luschka applied the term "parametrium." Frankenhäuser's[2] dissections corroborated the results of Luschka's investigations.

W. A. Freund,[3] among others, has employed the second method—plane sections of frozen or spirit-hardened pelves. His investigations have added much to the physiological and pathological dignity of the parametrium. This structure he describes in the following words:

"The peculiar configuration of the tissues just mentioned appears most distinctly in a transverse section directed through the internal os and obliquely backward, through the base of the broad ligaments; the structure, also, of the different extensions of the connective tissue becomes apparent in the transverse section. Such a section shows a star-shaped figure with long-drawn-out side rays, with finger-points grasping in flat arches the bladder in front and the rectum behind, with short, lopped-off pillars crowded in proportion to the space between uterus and bladder, and still more between uterus and rectum. This considerably firmer structure offers an external scaffold for the upper portion of the vagina, the uterus, the broad ligaments, and mediately for the bladder and rectum; it secures a firm support to the blood-vessels, stretched out lengthwise from the sides of the uterus, and the lymph-vessels, richly distributed in this region; a safe bed to the nerve-twigs and large ganglia scattered about; a point of attachment to the ureter in its course through the basis of the broad ligament; and serves, in the most important way, in the loose pelvic connective tissue next to organs exposed to such great evolutions of movement and nutrition, in the preservation of the normal form and functional activity of the pelvic organs."

Inflammation of the pelvic connective tissue, while occurring at all periods of life—before puberty and after senile involution—is observed most frequently during the time of sexual activity, particularly during the puerperium, after abortion, or labor at term.

It is a difficult, if not an impossible task, in the present state of our knowledge, to make a classification of pelvic cellulitis upon an etiological principle of division that does not involve essential contradictions, or that is not largely hypothetical. Notions of the causation of the inflammation have been obscure and confused until within a comparatively recent period of time, and are still far from adequate. Emmet's[4] views upon this topic are of peculiar interest, and now of historical value, exercising, as they do, such a dominant influence upon American gynecology. Apart from the "lesions incident to the puerperal state," he looks to pathological changes in the connective tissue as the immediate cause of the results we now regard as the original disease in the uterus and ovaries. He is deeply impressed with the belief that "the point of origin of inflammation in the pelvic cellular tissue is in the veins." He, however, in common with other observers, recognizes a marked difference in the forms of cellulitis—a difference independent of locality and constitutional state, but explicable by the hypothesis of difference in the immediate exciting causes. The researches of Ogston, Hueter, Rosenbach, and others have rendered in a very high degree probable, if not positively demonstrated, the theory that all suppuration is due to the action of microbes. The modern theory of infection is invested with the same etiological dignity in connection with pelvic cellulitis that it has been demonstrated to possess in relation to pelvi-peritonitis. Two forms of acute inflammation of the pelvic connective tissue stand out sharply differentiated as regards structural changes and clinical course, although the exact nature of the etiological difference is still somewhat obscure. These forms are: 1, Benignant parametritis (Schroeder) or simple phlegmon (Freund), and 2, infectious parametritis (Schroeder) or septic phlegmon (Freund).

1. *Benignant Parametritis*, or *Simple Phlegmon.*—The conditions necessary to the production of a simple phlegmon of the pelvic connective tissue are trauma of the genital tract and infection with the bacteria of putrefaction (Landau, Spiegelberg). These conditions are chiefly supplied by abortion, labor at term, and various operative procedures. Given a solution of the continuity of the tissues that is not infected by specific, septic microbes, and a local inflammation in the vicinity of the wound results. As remarked by Schroeder, the surgical axiom that local irritants produce inflammations only at the site of irritation, and that general causes call forth general inflammations, holds true, also, with reference to the pelvic connective tissue. The extent of the infiltration obviously depends largely upon the nature of the wound, whether incised, contused, or lacerated. Its site depends upon the region of the genital tract injured. Lesions of the cervix are followed by parametritis; wounds of the vagina, by paracolpitis; injuries of the peripheral fatty connective tissue, by peripheral pelvic phlegmons.

Simple parametritis, uni- or bi-lateral, frequently the result of cervical tears, has its primary seat in the lateral connective tissue at the base of the broad ligament, adjacent to the supravaginal portion of the cervix, surrounding by election the posterior aspect. The infiltration extends outward toward the pelvic walls, unfolding the broad ligaments until it reaches the peripheral fatty connective tissue. At this point it may be abruptly bounded, or it may pass over into the connective tissue of the iliac fossa. The connective tissue about the rectum is sometimes involved, but the paracystium is only implicated in the severer cases. The infiltration, after persisting for a variable period, undergoes resolution, or is transformed into pus. The pus is usually evacuated by sieve-like perforations through the posterior vaginal fornix, difficult of discovery, or into the rectum in the neighborhood of the third sphincter. The residual, nodular masses of infiltrate, not transformed into pus, ultimately undergo resorption, although they may remain indefinitely in an apparently unchanged condition.

Simple paracolpitis, frequently observed as the result of fistulous wounds of the vagina, has its primary seat in the connective tissue to the sides of, and behind, the vagina. The connective tissue corresponding to the anterior wall is seldom extensively involved. Upward, the infiltration may extend to the parametrium, and laterally, to the pelvic diaphragm. Cicatricial contractions in the connective tissue of the paracolpium, causing the formation of vesical diverticula on the anterior vaginal wall, and distortions of the shape of the vagina, particularly in the region of the ischiatic spines (Freund), are among the important residua of partial resolution of the phlegmon.

Freund mentions the violent extraction of the head in labor, and the enucleation of large, submucous myofibromata, as two principal factors in the production of injury to the peripheral fatty connective tissue. The infiltration follows along the lateral and posterior aspects of the pelvic cavity, immediately below the internal arcuate line. Thence it spreads in the direction of, but never reaches, the cervix. Posteriorly, the infiltration passes through the great sciatic foramen, implicates the connective tissue of the paraproctium, then passes anteriorly in the region of the os pubis up into the paracystium. Below, it is bounded by the levator ani; above, the external portions of the broad ligament are unfolded, and the iliac fossæ are, in the severer cases, involved.

The terminations of these phlegmons will be discussed more in detail under another heading. It may be mentioned, however, incidentally, that the pus from the transformation of one of these peripheral phlegmons frequently points through the great sciatic foramen, external to the pelvic cavity, as in the gravitation-abscess.

In simple phlegmon the pelvic peritoneum is always involved in some degree, but the inflammatory process is of a benignant character. Compared with infectious parametritis, simple phlegmon is of very infrequent occurrence. On account of the local character of the symptoms it is apt to be overlooked—at least during the early stages.

2. *Infectious Parametritis*, or *Septic Phlegmon.*—The necessary conditions of septic phlegmon are a lesion of the genital tract, and its infection by the specific, septic microbes. These conditions are supplied almost exclusively by abortion or labor at term—gynecological operations being responsible for a relatively small number of

cases. Given a wound surface in the genital tract and its infection by specific, septic microbes an inflammatory infiltration occurs in the vicinity. The inflammation may remain thus localized. Usually, however, the process is propagated by continuity of tissue, or through the media of the veins, lymphatics, and connective tissue. Accordingly three forms of the disease, more or less distinctly separable anatomically and clinically, arise, which Buhl (1861) designated as follows:

1. Puerperal peritonitis without pyæmia (kolpitis, endometritis, salpingitis, pelvi-peritonitis).

2. Puerperal pyæmia without peritonitis (metro-phlebitis).

3. Puerperal pyæmia with peritonitis (lymphangitis, parametritis, pelvi-peritonitis).

The first form will be briefly discussed in connection with pelvi-peritonitis. In puerperal pyæmia without peritonitis, the septic poison gains access to the veins, the inflammatory process is propagated through the pelvic connective tissue as a metro-phlebitis and periphlebitis, with thrombosis of the pampiniform and spermatic plexuses. These cases of *sepsis foudroyante* frequently terminate fatally within a short period after infection, before extensive infiltrations of the pelvic connective tissue occur. Virchow,[5] in particular, has studied exhaustively the third form, to which he has given the name, erysipelas malignum puerperale internum, seu para-uterinum. The inflammatory process is propagated as a metro-lymphangitis, perilymphangitis, with lympho-thrombosis. The connective tissue is infiltrated in an irregularly progressive, migratory manner, analogous to the course of erysipelatous subcutaneous phlegmons. The septic process invades, in rapidly destructive suppuration, when the patient survives, the retro-peritoneal connective tissue up to, and beyond, the kidneys, the subperitoneal connective tissue of the anterior abdominal wall, and the connective tissue of the thighs. The pelvic peritoneum is attacked, through the subperitoneal connective tissue at the sides of the uterus, early in the course of the disease. Under these conditions the tubes become inflamed from the ostium abdominale toward the uterine orifice.

The discussion of the pathology of simple and septic phlegmon would be incomplete without an allusion to phlegmasia alba dolens, a phenomenon of not infrequent occurrence in the course of both affections. In simple milk leg following the infiltration of the connective tissue of the anterior portion of the pelvis, lymph-stasis occurs, producing swelling of the affected labium majus and upper half of the thigh, with disappearance of the vulvo-femoral fold. The skin is white, or pale yellow, and pits slightly on pressure. The part is painful, spontaneously and on pressure. If the pelvic infiltration ends now in resolution, the lymph undergoes resorption. If the infiltrate remains in an unchanged condition or increases in amount, the phenomena of pressure thrombosis of the femoral veins are added. The entire lower extremity begins to swell from the toe and foot upward. The enlarged veins are visible through the shining, mottled skin; œdema is marked. Freund has demonstrated the truth of this explanation of milk leg by the following simple experiment. Puncture of the skin of the upper third of the affected thigh yields pure lymph, only slightly tinged with the blood from the cutaneous wound. Puncture of the skin of the foot, on the other hand, yields a purely serous exudate, without corpuscular elements. In septic phlegmasia alba dolens, the stage of lymph-stasis is not present at all, or it is very brief and obscured by the rapidly developing pressure, venous thrombosis. The infiltration advances at once from within the pelvic cavity to the connective tissue of the thigh.

The residual abscesses and exudates of septic phlegmon chiefly concern the gynecologist. The investigations of König[6] and W. Schlesinger[7] are of especial importance with reference to the distribution of the pelvic connective tissue and the paths that blood, pus, and fluid, or semi-fluid exudates in general are apt to select. The method employed, originally practised by Bichat and Henke, consists in the injection of air and various fluids into the pelvic connective tissue.

König used the cadavers of women dying shortly after the puerperium, from causes bearing no necessary relation to the lying-in period. He injected air or water by means of fine cannulæ beneath the pelvic peritoneum. His results, corrected by clinical observation, are:

1. An exudate developing itself in the connective tissue of the broad ligament, in the vicinity of the tubes and ovaries, extends primarily in the direction of the psoas and iliacus, and subsequently descends into the pelvis minor.

2. Exudates which develop primarily in the antero-lateral region around the internal os first fill up the connective tissue of the pelvis minor, laterally, from the the deeper portions of the uterus and bladder, and thence extend around the round ligament in the direction of Poupart's ligament under the inguinal ring. Thence they extend into the iliac fossa, outward and backward.

3. Abscesses, originating in the posterior base of the broad ligament first fill up the postero-lateral portions of the pelvis (Douglas's cul-de-sac), and then follow the course described in 1.

4. Later these differences disappear, since the portions of the peritoneum named are all equally lifted up.

5. When pus burrows along Poupart's ligament, the peritoneum is dissected up from the ligament by a very small quantity of fluid, so that a puncture of the abdominal wall one and a half finger-breadth above the ligament falls without the peritoneum.

W. Schlesinger, using the cadavers of women who had never passed through the puerperium, injected the connective tissue with colored fluids, such as filtered plaster-of-Paris, glue, and the like.

Some of the conclusions arrived at by these experiments, briefly stated, are:

1. Injections into the anterior lamella of the lateral section of the broad ligament spread out the leaves of the ala vespertilionis, especially in the direction of the abdominal end of the tube, so that even the fimbriæ of the morsus diaboli swell out into little tumors. The fluid then presses the folds of the broad ligament wider apart and reaches the linea terminalis before the tumor caused by the infiltration has obtained very considerable dimensions. From this point—where the peritoneum of the broad ligament is continuous with the peritoneum covering the iliac fossa—the extension of the injected matter occurs in the two following ways:

a. The fluid situated upon the psoas pursues an oblique course forward, following, but to the outer side of, the round ligament, in the direction of the lateral half of Poupart's ligament, so that the infiltration is bounded in front and internally by the elevated round ligament.

b. Another portion of the fluid, after passing the vessels, infiltrates the connective tissue surrounding the cæcum on the right side, the mesentery of the sigmoid flexure on the left side, thence passing upward and to the outer side of the ascending and descending colon.

2. A lateral injection through the posterior lamella of the broad ligament, in the region of the internal os, infiltrates the connective tissue of the base of the broad ligament and within the pelvic cavity, laterally and posteriorly. The posterior lamella of the broad ligament, ultimately the pouch of Douglas, pouts downward and outward on the side injected. Thence the fluid passes over the vessels until the iliac fossa is reached, when the course, sub 1, is pursued. The infiltration passes upward behind the ascending and descending colon, toward the kidneys, before moving forward in the direction of the round ligament.

3. An injection through the anterior lamella of the broad ligament to the side of the cervix, on the plane of the internal os, passes into the connective tissue between the anterior uterine wall and the posterior vesical wall, frequently crossing over the median line. Thence the infiltration passes in front of the round ligament corresponding to the side of injection, toward the inguinal ring. Another portion of the injection unfolds the broad ligament, lifting up the peritoneum of the lateral pelvic wall behind the broad ligament.

4. An injection into a fold of the peritoneum, in the median line of the vesico-uterine fossa, spreads itself out in a transverse direction in the connective tissue, under the vesico-uterine peritoneum. The infiltration is not symmetrical, but is more extensive on the one side than on the other. The peritoneum of the posterior vesical wall is elevated. The infiltration reaches the round ligament and is bounded for a time by this structure; thence it passes behind and beneath the round ligament to the side of the pelvis, lifting up the peritoneum in its course as in 3.

5. A lateral injection under the mucous membrane of the vaginal portion, on a level with the vaginal insertion, causes a swelling that is convex, laterally and anteriorly, toward the vagina, and increased resistance in the antero-lateral portion of the pelvis, behind the lateral segment of the posterior vesical wall. Thence the fluid penetrates between the bladder and uterus, lifting up the peritoneum of the posterior vesical wall, and filling up the deeper-lying layers of connective tissue of the base of the broad ligament, immediately above the vaginal fornix.

6. Injection into the median line, along the anterior uterine wall, on a level with the vaginal insertion, produces at first a circumscribed swelling at the point of injection. Thence the infiltration fills up the connective tissue between the uterus and bladder, elevating the peritoneum in its course. From this point it proceeds transversely, involving the connective tissue of the base of the broad ligament, more on one side than on the other.

7. An injection made close to the posterior lip of the uterus, between the vaginal wall and cervix, in such a manner that the cannula lies immediately below the peritoneum, results in a slight infiltration of the connective tissue corresponding to the folds of Douglas's pouch, elevation of the peritoneum from the posterior vaginal wall, or the elevation of the peritoneum and infiltration of the subjacent connective tissue corresponding to the rectum.

The results of the laborious investigations of König and Schlesinger agree in the majority of essential particulars, and correspond, in the main, with the symptoms during life and the objective findings after death. They are accordingly entitled to a very high degree of consideration. It must be admitted, however, that the character of the lesion of the genital tract and the anatomical peculiarities of the individual have an important influence upon the path selected by fluid or semifluid exudates. Then septic inflammations, as remarked by Freund, do not respect anatomical boundaries, but involve fasciæ, aponeuroses, muscles, glands, vessels, and nerves alike in the process of destructive suppuration. Finally, the blood-vessels and lymphatics play a rôle in the spread of an infiltration that cannot be estimated in such experiments upon the cadaver. The experiments indicate the paths of least resistance and the direction in which gravitation-abscesses point.

Symptoms. — *Simple Phlegmon.* — The attack begins[8] without prodromes, within four or five days after labor, or the operation of the exciting cause. Pelvic pain, elevation of bodily temperature with or without a chill, and acceleration of pulse and respiration mark the onset.

The pelvic pain, spontaneous and on movement, occurs suddenly, and is usually referred to the left side, a fact attributed to the relative frequency of first positions in vertex presentations. It radiates from the uterus, according to the site of the inflammation, toward the sacrum, lumbar region, os pubis, iliac fossa, or down the lower extremity. The pain increases gradually in intensity, but, while sharp, is not so acute as in pelvi-peritonitis. Vesical and rectal tormina and tenesmus, in some degree, are almost always present.

The elevation of temperature seldom reaches 104° F. The fever is of a continued type. The pulse beats from one hundred to one hundred and twenty times to the minute, and is full and regular when the peritoneum is not involved.

The duration of these symptoms, of course, is very variable, but seldom exceeds one week.

At the expiration of one or two days the formative changes—the infiltration of lymph—occur, and a swelling appears, usually in the connective tissue of the base of the broad ligament, pursuing the paths already described. The presence of this exudate is the only characteristic sign of the phlegmon. The extent of the infiltration bears some relation to the intensity and duration of the pain and fever. This relation, however, is by no means constant and is seldom necessary. Many observers agree with Emmet that extensive phlegmons may develop without causing any particular disturbance.

The locality and size of the infiltrate determine the symptoms arising from pressure upon the pelvic viscera. The effect of simple phlegmons, when bilateral and of considerable size, upon these organs, blood-vessels, nerves, and lymphatics, is obviously serious. Compression of the ureters, sometimes resulting in hydro-nephrosis and pyelo-nephritis, partial occlusion of the rectum,—very rarely causing symptoms of ileus,—fixation of the uterus with lateral displacements after cicatricial contraction, circulatory disturbances in the uterus, bladder, rectum, and lower extremities, and pelvic neuralgias are among the more important sequelæ.

The very large majority of simple phlegmons terminate in resolution, more or less complete, and suppuration is an exceptional occurrence.

Septic Phlegmon.—The clinical picture of septic phlegmon resembles that of septic pelvi-peritonitis, in being composed of two elements, the local pelvic lesion and the constitutional effect of the septic poison brought about through the medium of the circulation. The second element, of course, is of chief significance with reference to symptoms and prognosis. The attack begins suddenly on the second or third day after labor, for example, and is characterized by pelvic pain, high fever with rigors, acceleration of pulse and respiration, and profound constitutional depression.

The pelvic pain, radiating from the uterus, is more general and agonizing than in simple phlegmon, owing to the rapid extension of the inflammation and the frequent implication of the peritoneum. It is frequently, however, of briefer duration, owing to the effect of the septic poison in obtunding the sensibility of the nerve-centres. In character it has been compared not inaptly to the pain accompanying the growth of malignant uterine neoplasmata. Fever of great intensity, 104° to 105° F. and even higher, is usually present. The type is continued. In some rare cases a subnormal temperature may exist from the beginning of the attack. These cases usually terminate fatally soon after infection, and the phenomenon is explained by the action of the septic poison on the heat-centres of the brain. It is only possible to make general statements as to the duration of the fever. According to Olshausen's investigations the duration was eight days in seventy per cent. of all cases; fourteen days in twenty per cent.; the duration was longer than two weeks in only ten per cent.

The acceleration of the pulse corresponds in general to the elevation of temperature, varying from one hundred to one hundred and forty beats to the minute. The acceleration of the pulse may result from a variety of causes apart from the one under discussion, *e.g.*, psychic disturbances, anæmia, and the like. Very great frequency of the heart's action—one hundred and forty to one hundred and eighty beats to the minute, especially with low or falling temperature—is of very grave prognostic moment, indicating, as it does, systemic poisoning. On the other hand, normal pulse-frequency, even with high temperature, is usually a favorable sign.

Upon the whole, it may be said that the force and frequency of the heart's action is a sign of greater prognostic moment than elevation of temperature in the disease under consideration. As remarked by Credé,[9] "High fever is not nearly so serious a symptom as great frequency of pulse."

Profound prostration of all the physical powers is observed in the highest degree when the septic poison gains access to the veins, giving origin to puerperal pyæmia without peritonitis, or sepsis foudroyante of the French writers. Credé[10] has graphically described the

complex of symptoms in a recent monograph, of which incidental mention has been made. As soon as a large number of the red corpuscles have been disorganized, the temperature reaches its maximum elevation, or, in exceptional cases, becomes subnormal, with rigors at irregular intervals. The entire body, attacked in its noblest cells, battles with all its powers against the enemy, but soon exhausts itself. The pulse becomes more frequent, flickering, confluent, increasing in frequency as the temperature falls (Kreuzung zum Tode). The functions of the alimentary canal are arrested; paralysis of the intestinal walls follows, with the development of gas and the accumulation of fæces, dyspnœa to the point of asphyxia, vomiting of the gastric contents and bile, involuntary dejections of acrid, serous, intestinal secretions, and fluid fæces. Cold sweats, extreme exhaustion, and great sensitiveness of different regions of the body, especially of the abdomen and pelvic region, are apt to follow; or, on the other hand, euphoria and complete anæsthesia, delirium, and convulsions are added; bed-sores appear on the gluteal regions from long continuance of the body in the dorsal decubitus.

The urine, sparingly secreted, contains an increased quantity of urea, and the biliary coloring matters, albumen, and tube-casts. The amount of the chlorides is diminished.

Murmurs are heard over the cardiac area, due to the paralysis of the trabeculæ, in the absence of ulcerative septic endocarditis.

When the pelvic lymphatics and connective tissue are primarily involved, as in puerperal pyæmia with peritonitis, the progress of the inflammation is slower. The battle[11] between the cells and the bacteria may be actively waged for a considerable period within the pelvic cavity. The bacteria, in very many cases hemmed in on all sides by the infiltrates, perish, and the septic process may remain a local one, with many of the symptoms and terminations of simple phlegmon. If, however, the bacteria pass beyond the limits of the pelvic lymphatics into the general lymph-channels, profound organic disturbances arise in remote organs, as the heart, lungs, kidneys, and brain.

Convalescence is extraordinarily slow. The fever abates slowly, and is subject to many irregular exacerbations and remissions. Very frequently it terminates in a hectic form, with morning remissions and exacerbations toward evening, or the so-called typus inversus is observed.

After apparent convalescence and an interval of complete apyrexia and absence of pain, during which the patient may have resumed her former duties, the process is frequently lighted up anew, with the reappearance of chills, fever, and pelvic pain. The connective tissue of one side of the pelvis having been involved, a very trivial cause is sufficient to determine the involvement of the opposite side. These relapses are not limited in point of time by days or weeks, but extend through months and even years.

The objective findings upon bimanual palpation, as before remarked, correspond in the main with the experimental results arrived at by König and Schlesinger from the injection with various fluids of the pelvic connective tissue in cadavers. Bandl's[12] clinical observations with reference to the location, size, and form of pelvic exudates are of peculiar interest in this connection, derived, as they have been, from a very large material, and confirmed or corrected, in many cases, by autopsies.

Bandl's conclusions are briefly: 1. The connective tissue of the base of the broad ligaments, to the sides of the uterus, is the most frequent site of the exudate. The infiltrate, on one or both sides of the uterus, about the size of a hen's egg, is wedge-shaped, with the base to the side of the uterus, the apex running out between the folds of the broad ligament, and is palpable through the abdominal walls in thin subjects, and per vaginam in all cases. These exudates are observed during the puerperium after lacerations of the cervix, and after operations on that organ.

2. Exudates, the size of one or even two fists, of irregular form, are observed in the connective tissue of the broad ligament, midway between the uterus and the lateral pelvic walls. The uterus is pushed to the opposite side, and the tumor is palpable through the abdominal walls.

3. Masses of irregular form and of large size are located in the iliac fossæ. The tumor, when large, is visible and palpable through the abdominal walls. In these cases, the infiltrate extending from the uterus through the broad ligament has undergone partial or complete resorption, a fact important to bear in mind, since an abscess arising in this region at a later period has been mistaken for a primary condition.

4. Irregularly shaped masses are found extending from the collum uteri to the lateral pelvic and anterior abdominal walls, along the course of the round ligament.

5. The parametrium is completely filled up with masses of exudate, the infiltrate occupying the connective tissue surrounding the supravaginal portion of the cervix, producing complete fixation of the uterus. The anterior and posterior vaginal fornices are flattened out, or are convex downward. The pelvic roof is as hard and tense as a deal board, to use one of Doherty's[13] expressions. The tumor is palpable through the vagina, and, when large or in thin subjects, through the abdominal parietes.

6. Exudates proceeding from Poupart's ligament into the connective tissue of the retro-peritoneal space and anterior abdominal wall are of infrequent occurrence.

7. Exudates occupying the lateral and posterior peripheral fatty connective tissue, immediately below the internal arcuate line, extending toward, but not to, the cervix, are seldom observed.

8. Paravaginal phlegmons occupy the posterior and lateral aspects of the paracolpium, seldom passing anteriorly or upward toward the parametrium.

9. Finally, Schultze and Emmet have called attention to the fact that the connective tissue of the utero-sacral ligaments is often involved, and have designated the process as parametritis posterior.

The terminations of pelvic phlegmons are various. It may be parenthetically remarked, right here, that in many cases, particularly in septic phlegmons, it is impossible to sharply differentiate the three stages of inflammation of systematic writers—temporary hypertrophy, formation of lymph, and formation of pus. Suppuration in many cases follows immediately upon the primary congestion.

The well-recognized terminations are:

1. The exudates may persist for months and years in an apparently unchanged condition. Small processes may undergo resolution, but the great mass of the phlegmon remains stable. Various disturbances in connection with the pelvic viscera, blood-vessels, lymphatics, and nerves arise, especially at the time of menstruation or during the early months of pregnancy, according to the size, form, and location of the exudate.

2. The exudate is transformed in part or entirely into pus. This is, however, a relatively infrequent termination. Out of 400 cases of pelvic peritonitis and cellulitis occurring in the hospital and private practice of Mundé, 48, or twelve per cent., terminated in abscess-formation.[14]

The transformation into pus begins in multiple,[15] small, disseminate foci, which may undergo resorption, or, flowing together, constitute one large abscess. The commencement of suppuration is usually indicated by the well-known symptoms of exacerbations of hectic fever, chills, and sweats, although it is frequently impossible to detect fluctuation within the exudate. The symptoms are due to the entrance into the circulation of some of the elements of pus. This explanation of the causation of the symptoms is rendered probable by the following facts: Small foci of pus, which have apparently existed for a considerable period of time, are frequently found within exudates after death; the pus exhibits all stages of retrograde metamorphosis; the fever and other symptoms are not accompanied by any extension of the exudate; an abscess may point, for example, in the vicinity of Poupart's ligament and then may, without rupture, undergo resorption (Bandl).

The part toward which parametritic abscesses point, and through which the pus is evacuated, is obviously a matter of considerable practical importance. The vault of the vagina seems to be the point of election in the majority of cases. Intermittent discharges of pus through this tube are frequently observed, when it is impossible to discover the minute, sieve-like perforations in the vaginal roof. Out of the 48 cases collected by Mundé, 5 opened spontaneously into the vagina. Pus may burrow in the direction of and above Poupart's ligament; and pointing and evacuation may occur at the junction of the outer with the middle third. Perforation into the rectum, on the plane of the third sphincter or lower, is less frequent, although out of Mundé's 48 cases, 14 opened spontaneously into the rectum. Mundé's cases, however, include both perimetritis and parametritis. The bladder is the point of selection next in order of frequency. Three of Mundé's cases terminated by spontaneous rupture into the bladder.

Pointing of subperitoneal abscesses has been observed in the vicinity of the navel (Leopold, Lomer), in the lumbar region to the outer side of the quadratus lumborum (Meinert), through the obturator and sciatic foramina, in the labia majora, perineum, and ischio-rectal fossa, and below Poupart's ligament, following the sheath of the psoas, but such cases are of infrequent occurrence. The abscess, finally, may rupture into the peritoneal cavity, usually causing a rapidly fatal general peritonitis. The quantity of pus is variable—sometimes only a few drops or drachms—depending upon the relation between the different foci of softening, whether confluent or not. Spontaneous cure seldom follows spontaneous rupture of the sac. The cavity, except in case of rupture into the vagina, is seldom adequately drained, and irregularly intermittent discharges through sinuous tracts, frequently multiple, are kept up for an indefinite period.

3. The exudate is liable to various infections.

The foci of softening exudate sometimes undergo ichorous changes—a metamorphosis fortunately of infrequent occurrence.

The causes of this change are very obscure in the majority of cases. After rupture of the sac, it is possible that the ichorous metamorphosis is due to the infection of the pyogenic membrane during surgical interference. Olshausen has observed this degeneration in exudates in the iliac fossæ, and refers the phenomenon to the diffusion of intestinal gases, which determine the decomposition of laudable pus. In the case of intestinal fistulæ, fæcal matter may gain entrance into the abscess-cavity. Whatever the cause may be, the effect is most disastrous to the patient. Such cases usually terminate fatally at an early date, with symptoms of marasmus or septicæmia.

The exudate, especially after it has undergone caseation or coagulation-necrosis in part or throughout its entire mass, is liable to tuberculous infection. The bacilli of tuberculosis may proceed from other regions in the patient's body, or may be introduced from without. Examples of auto-infection are found in the tuberculization of parametritic phlegmons [16] from tuberculous caries of the pelvic bones, vertebræ, and hip-joint, and from tuberculosis of the mesenteric glands, intestines, peritoneum, and Fallopian tubes. Coition may be mentioned as a mode of hetero-infection.

Given the tuberculization of an extensive exudate, and the conditions for the dissemination of the disease through the media of the blood-vessels and lymphatics are obviously favorable.

Parametritic, as well as perimetritic, phlegmons may become infected by the actinomyces bovis (v. Hacker, Zehman).

4. The phlegmon may terminate in resolution—unfortunately of rare occurrence in septic phlegmons. In simple phlegmons, complete resorption of the exudate is more frequently observed.

As remarked by Emmet,[17] a most extensive phlegmonous cellulitis may be detected after childbirth, which will sometimes rapidly disappear within the course of a few days, and we frequently meet with like cases in the non-puerperal state.

Diagnosis.—The absolute recognition of an intra-pelvic exudate, either by direct palpation through the abdominal parietes or on bimanual palpation, usually involves no especial difficulty.

The differential diagnosis between intra- and extra-peritoneal exudates is always difficult, and not infrequently impossible. This fact is well illustrated by the following anecdote, narrated by Emmet: [18]

"During the past winter, Professor Polk kindly invited me to witness an operation, in his service at Bellevue Hospital, for the removal of a diseased tube. The patient had suffered from a double laceration of the cervix uteri, and I had, at a previous examination, expressed the opinion that the subsequent condition was one of thickening and shortening of the left broad ligament from an old cellulitis. At the operation, to my surprise, no broad ligament was found, and the enlarged tube lay directly against the side of the vagina. The relative position, or line, with the fundus of the uterus and the ovary remained unchanged, and yet the fingers of the operator, as they grasped the tube, could be distinctly felt from the vagina, and in contact with its walls. This was so marked an instance, that the explanation presented itself to me as soon as I was able to give the matter due thought. I recalled the fable of the two knights meeting at a cross-road, where a shield was suspended which was of gold on one side and of silver on the other. They disputed as to the material of which it was made. Each was right from his own stand-point, and all difficulty could have been avoided if either had looked on the other side." The fable of the knights is not exactly apropos in connection with the case mentioned, since the diagnosis of the one medical gentleman was clearly right, while that of the other medical gentleman was clearly wrong.

The locality of the exudate is probably the most important sign in the differential diagnosis. In parametritis the exudate is most frequently observed along the sides of the collum uteri, with flattening or projection downward of the anterior and lateral vaginal fornix; in pelvic peritonitis the exudate occupies the cul-de-sac of Douglas, or is frequently found above the plane of the inlet in the iliac fossæ.

In parametritis, fixation of the collum uteri with relative mobility of the fundus, exists from the beginning of the attack; in pelvi-peritonitis, the fundus and corpus are fixed, with relative mobility of the uterine neck. Elevation of the uterus is accompanied by greater pain in parametritis than in perimetritis, although, in general, there is less sensitiveness to pressure in the former than in the latter affection.

Parametritis is frequently bilateral, involving the connective tissue symmetrically. Perimetritis is frequently unilateral—left side—or developed in an asymmetrical manner.

The consistency of the exudation in parametritis is firmer, more resisting—from the circumscribed space as well as owing to other anatomical peculiarities—than that of perimetritis.

The etiology of the affection frequently throws light upon the diagnosis. A pelvic exudate, occurring in the course of gonorrhœa, will probably be intra-peritoneal.

All of these signs, however, are purely relative, and aid only in the establishment of a more or less probable diagnosis. This fact is not at all remarkable, since, as remarked by Schroeder, the decision even in autopsies is sometimes difficult, because intra-peritoneal exudates may be surrounded by a newly formed membrane that bears a great resemblance to the peritoneum. Then primary inflammations of the pelvic peritoneum, when of an intense degree, are almost invariably accompanied by pelvic cellulitis. On the other hand, primary inflammations of the pelvic connective tissue almost always involve the peritoneum to a greater or less degree. The most notable exception to this proposition is found in those rare cases of sepsis foudroyante in which the septic poison gains direct access to the veins, and the inflammatory process is propagated through the parametrium as a metro-phlebitis. Under these conditions the peritoneum

frequently exhibits not the slightest trace of inflammation. But then the course of the affection is so rapid that the involvement of the pelvic connective tissue is minimal.

However desirable an exact differential diagnosis between intra- and extra-peritoneal exudates may be from a prognostic point of view, the remedial measures for both conditions are practically identical.

The diagnosis of suppuration and abscess-formation is made, probably, in the majority of cases, after rupture of the sac and the evacuation of its contents, by the observation of irregularly periodical discharges of pus through the channels already indicated.

Before rupture the diagnosis is based upon exacerbations of hectic fever, rigors, night-sweats, together with certain local changes in the exudate. These changes are fluctuation or sudden increase in the size of the tumor, with or without softening. But all of these signs may be absent.[19] Large abscesses, containing more than a pint of pus, may form without fever, rigors, and night-sweats. Then, in many cases it is impossible to detect fluctuation, and the difference in the size and consistency of the tumor may be imperceptible. The foci of softening are originally small and disseminate, and are surrounded by masses of callous exudate.

Under these conditions, there are two methods by which the presence of pus in the circum-uterine exudate may be determined—exploratory puncture through the vagina, and exploratory abdominal section.

The dangers of exploratory puncture by the vagina are minimal when a fine capillary needle is selected, and the operation is conducted with proper antiseptic precautions. But the pus may be so thick or slimy that it will not pass into the needle, or the exudate may be situated so high up in the pelvis that it cannot be reached.

The last recourse is then to exploratory abdominal section. Exploratory puncture through the abdominal parietes is contraindicated, as in the tapping of supposed ovarian cystomata, by the great danger of the escape of pus into the abdominal cavity upon the withdrawal of the aspirator-needle. The indication for exploratory abdominal section under these conditions is well stated in Fenger's[20] words: "I do not wish, however, to be understood as being an advocate of indiscriminate laparotomy for peri-uterine exudates, or for mere satisfaction of a diagnosis; but I want this measure limited, of course, to obstinate chronic cases, in which the very pertinacity of the exudate, even if no fever is present, indicates pus somewhere in the centre of it, and makes the patient a confirmed invalid."

In the diagnosis of parametritic abscess, it is necessary to bear in mind the fact that collections of pus, originating in caries of the vertebræ or pelvic bones, or in perityphlitis, may burrow, under the influence of gravitation, downward into the parametrium.

Subperitoneal fibromyomata, small ovarian and parovarian cystomata, pregnancy, and other anomalies of the tubes, and extra-peritoneal extravasations of blood, may simulate parametritic exudates.

Fibromyomata can usually be excluded by their more or less smooth, round form, mobility, insensitiveness to pressure, consistency—exudates being either softer during suppuration, or harder after partial resolution and thickening. The clinical history of the course of the affection also throws some light on the question. Ovarian cysts and tumors in connection with the tubes are situated higher up in the pelvis, are relatively round and movable, and differ in consistency from both exudates and fibroids.

If, however, a fibroid or a small ovarian cyst deep down in the pelvis becomes inflamed, the differentiation is frequently impossible.

Extra-peritoneal extravasations of blood are distinguished by the suddenness of the onset, by the absence of fever, and by other signs of constitutional disturbance during the early stages; they are further distinguished by the rapid resorption of the extravasation, and by the history of the case with reference to causation. Later in the course of the affection inflammation may occur, and the blood-extravasation may act as the cause of a true parametritis.

3. *Chronic Atrophic Parametritis, Circumscribed and Diffuse.*—By this term, Freund[21] designates a peculiar chronic inflammation of the parametrium, distinctly marked out anatomically, and clinically appearing under the forms of circumscribed and diffuse induration, identical in nature with sclerosis or cirrhosis in other organs, as the liver, spleen, kidneys, lungs. The hyperplasia and subsequent contraction of the connective-tissue elements produce structural changes and functional phenomena in the pelvic viscera similar in kind to those observed in other organs subject to the granular-atrophic process.

1. *Circumscribed Chronic Atrophic Parametritis.* This form occurs at all periods of life, from puberty to the menopause.

The etiological factors are chronic ulcerative inflammations of the bladder, rectum, and uterus. Ulcerations of the bladder frequently result from the trauma of labor, from unskilful catheterization, and the like. In the rectum the inflammation may be caused by dysentery, or by simple catarrhal folliculitis, the usual site being on the anterior wall, in the region of the third sphincter. Lacerations of the vaginal portion and chronic inflammations without wounds are the starting-points in connection with the uterus.

The anatomical findings consist of cicatricial connective tissue, radiating from the viscus primarily affected in the paracystium, paraproctium, or parametrium. The mobility of the pelvic organs is limited to a greater or less degree, and displacements, particularly of the uterus and adnexa, result from the cicatricial contraction of the connective tissue. The character of the displacement depends, of course, upon the site of the degeneration. In paracystitis sinistra the cervix is drawn forward and to the left, while the corpus is turned or flexed posteriorly and to the right. In paraproctitis the degeneration follows the course of the utero-sacral ligaments forward to the posterior lip of the vaginal portion, and backward to the sacrum. In paraproctitis sinistra, the most frequent form, the cervix is drawn backward to the sacrum and to the left, while the corpus is turned or flexed forward and to the right. The connective tissue of the base of the broad ligaments is involved in parametritis, and the degeneration is propagated particularly in the horizontal plane, but it is more pronounced either in the direction of the rectum or in that of the bladder. The process is usually limited by the peripheral fatty connective tissue, but may pass downward to the laquear vaginæ. The character of the uterine displacement depends upon the direction in which the degeneration is most energetically developed. The cervix is drawn backward or forward, according to the side affected, while the corpus is turned or flexed in the opposite direction.

The ureter of the affected side, as it passes through the parametrium a little below the plane of the internal os, is turned forward and approximated to the cervical wall.

In the early stages of the degeneration the nutrition of the peripheral fatty connective tissue is not altered. Later, however, when contraction occurs, it becomes atrophic—dry, large-meshed, rarefied. The arteries, particularly of the parametrium, are separated from each other and surrounded by rings of contracting, cicatricial tissue; the veins are involved in chronic periphlebitis, resulting in varicose dilatations, thrombosis, and the production of phlebolites. The cervix is in a state of chronic inflammation; the profuse secretions from the canal indicate the presence of a catarrh.

2. *Diffuse Chronic Atrophic Parametritis.* This form occurs usually during the period of life from the thirtieth year to the climacteric. Occasionally it is observed at puberty, and after the change of life. It is of most frequent occurrence in married women who have borne children.

The etiology is obscure. Freund recognizes two factors, excessive sexual irritation of the genital organs, and the loss of the tissue-juices (*Säfteverlust*). These causes

are operative in masturbation, too frequent or reserved coitus, in individuals who are subject at the same time to diarrhœa, blennorrhœa, profuse perspirations, or hæmorrhages, or who, with inadequate food-supply are called upon to undergo extraordinary bodily and mental fatigue. Puerperia and lactations following each other in rapid succession, and the exercise of the sexual functions when a condition of genital and vascular hypoplasia exists, deserve mention in this connection. Freund is of the opinion that syphilis, gonorrhœa, and local lesions of the genital tract do not stand in any direct causal nexus.

In estimating the potency of masturbation, reserved coitus, and excessive venery, as etiological factors, it is well to bear in mind the fact that their influence has probably been exaggerated. Van de Warker,[22] after as careful and as complete a study of the Oneida community as circumstances would permit, could "discover nothing but negative evidence relating to the effect of male continence upon the health of the community." It will be remembered that the sexual functions were subjected by this strange group of men and women to all manner of perversions and excesses for a considerable period of time.

The left side of the pelvis is primarily affected in the large majority of cases. The degeneration begins in the connective tissue of the base of the broad ligament, proceeds downward to the laquear vaginæ, backward along the utero-sacral ligaments, and gradually passes out into the broad ligaments until all the pelvic connective tissue, inclusive of the peripheral fatty layer, is involved. In extreme cases the cicatricial atrophy may attack the subserous connective tissue of the anterior and posterior abdominal walls, especially the connective tissue of the mesentery of the colon. The bundles of cicatricial tissue flow together and constitute broad masses of resistant tissue, composed of bands "wound in and out in wave-like convolutions." The changes around the arteries, the uterine and pampiniform venous plexuses, are greater in degree, but similar in kind to those described under the circumscribed form of the degeneration. The portions of the ureters that pass through the parametrium undergo stretching, flexure, and infraction; they become tortuous and dilated, and at the same time are drawn forward and to the sides of the cervical wall. As the result of this profound disturbance of the pelvic circulation, corresponding structural and functional alterations occur in connection with the pelvic viscera. Venous hyperæmia, with ectasis of the blood-vessels, is observed in the more dependent portions of the pelvic organs, the urethra and neck of the bladder, the vaginal portion of the cervix, and the lower portion of the rectum.

The mucous membrane of these organs is in a state of chronic catarrhal inflammation. Ultimately the broad ligaments are shortened, the round ligaments are thinned. The uterus, ovaries, and tubes—and in exceptionally severe cases, the vagina and vulva—undergo atrophic changes similar in their general effect to those produced by age.

The pelvic peritoneum is involved in a benignant inflammation, in both forms of the affection, that usually leads to the formation of adhesions and pseudo-membranes.

Microscopical examination reveals the characteristic features of cicatricial hyperplasia of the interstitial connective tissue. The large cervical ganglion of Frankenhäuser is involved in a true perineuritis. The peri- and endo-ganglionic connective tissue undergoes hyperplastic changes, with the separation of the elements of the structure, partial destruction of the nerve-fibres, which lose themselves in the cicatricial tissue, and disappearance of the dark, pigmented, and irregularly shrunken ganglion-cells. No constant anomalies of other important organs are found with chronic atrophic parametritis.

Freund has noticed the co-existence of cirrhosis of the liver and granular atrophy of the kidneys, in several cases, but deems the relation inconstant and not necessary.

Symptoms.—In the following account of the clinical course of chronic atrophic parametritis, Freund's observations are recorded. The symptoms are divisible into local and general.

The first and most important local symptom is pelvic pain, radiating from the iliac region of the affected side, posteriorly, toward the nates, and anteriorly toward the mons veneris. In the severer cases the pain radiates downward along the inner surface of the thighs, and upward along the belly and trunk. The pain, at times spontaneous, is increased upon bodily exertion, coitus, vaginal exploration, and the like. The pelvic bones are sensitive to the pressure of clothing (pelviodynia), and the patient cries out upon assuming the sitting posture (coccygo-sacrodynia).

Various functional disorders arise in connection with the pelvic viscera—the result of interference with the circulation and nervous supply by the cicatricial retraction of the connective tissue. In paracystitis ischuria and dysuria are present; in paraproctitis tenesmus is aggravated by hæmorrhoids and rhagades.

Menstrual disturbances are constant. In the beginning, during the stage of venous congestion, menstruation is profuse, and catarrhal secretions escape from the uterine cavity during the interval. Later, the quantity of blood lost becomes less, the intervals longer, and the menopause may be prematurely established, as early as the thirtieth year in certain cases. All degrees of dysmenorrhœa—from a slight feeling of discomfort to violent, colicky pains—are observed. Intermenstrual pains are occasionally noted. The sexual functions undergo profound alterations. The patient is indifferent to the sexual act, when positive dyspareunia does not exist. Perversions of the sexual instinct are not infrequently observed.

After the cicatricial retraction of the connective tissue sterility is a usual consequence. When conception does occur, pregnancy exercises an important and favorable influence upon the degeneration, frequently effecting a restoration of normal nutritive relations.

The more important general symptoms are comprehended under the reflex neuroses. Three groups are distinguishable—sympathetic, spinal, and cerebral.

In each group there are sensory, motor, secretory, and trophic consequences; in each a stage of excitation, followed by a stage of depression or paralysis.

The sympathetic reflex neuroses—sympathetic hysteria—of most frequent occurrence, include a vast complex of symptoms—cœliac neuralgia, hyperæsthesia of the hypogastric plexus, cardialgia, enteralgia, nausea, vomiting, globus, salivation, pyrosis, dyspepsia, anorexia, tympania, the urina spastica, laryngismus, suffocatio, asthma, tachycardia, and the like. Under the vaso-motor disturbances referable to this group may be mentioned hæmorrhages of the alimentary canal, lungs, kidneys, uterus, ovaries, and tubes. Freund explains many cases of Graves' disease upon the ground of sympathetic hysteria, with vaso-motor complication of the heart, thyroid, and orbital connective tissue.

Under the group of spinal reflex neuroses—spinal hysteria—is included pain, spontaneous or on pressure, in the region of the spinous processes of the fourth and fifth cervical, third and sixth thoracic, fifth lumbar, and first sacral vertebræ, radiating, particularly on the left side, along the course of the spinal nerves. These symptoms are recognizable clinically as cervical, intercostal, lumbo-abdominal, and lumbo-iliac neuralgias. Later, neuralgic pains are experienced in the main trunk or branches of the sciatic—peroneal branch, crural; of the brachial plexus—ulnar; and in the nerves distributed to the joints.

Trophic disturbances are frequently added to the neuralgias. The mammary gland of the affected side is sometimes swollen and painful on pressure. Small, painful neuromata are developed in the course of the cutaneous nerves. Herpes zoster is a relatively infrequent phenomenon.

Wandering anæsthesia and perversions of sensibility are worthy of mention in connection with sensory changes. Spasms and contractures of certain muscles or groups of muscles—*e.g.*, the abdominal parietes, rectus abdominis, and the various hysterical paralyses are among the disorders of the motor function.

Among the vaso-motor disturbances, corresponding to spinal hysteria, are local hyperæmiæ, suffusions, ischæmiæ of the skin, bloody sweats, long continuing congestions of the spinal cord and meninges.

Of the cerebral reflex neuroses—cerebral hysteria—disorders of the trigeminus, copyopia hysterica (Forster) and various psychoses are the more important. The cerebral symptoms are observed late in the course of the disease, and are of least frequent occurrence.

The abnormal deposition of pigment and the circumscribed atrophy of the skin and subcutaneous connective tissue may be mentioned among the trophic disorders of cerebral hysteria.

Diagnosis.—The local diagnosis of circumscribed chronic atrophic parametritis rests upon the detection, by bimanual palpation, of the cicatricial connective tissue. In paracystitis the anterior vaginal laquear is flattened, and the base of the bladder is found in a state of fixation upon the introduction of a sound into that organ and an index finger into the vagina. In paraproctitis rectal exploration is of value in the determination of the nature of the changes in the pelvic connective tissue. In parametritis the neck of the uterus is fixed by the degeneration, and the entire organ turns around this focus, as on a pivot. The thickness, extent, direction, and peripheral attachments of the bands of cicatricial connective tissue are determined, under favorable conditions, upon bimanual palpation. The sensibility of the parts, spontaneous and on pressure, is greatly increased, and is, in a measure, characteristic.

The residual adhesions and pseudo-membranes of pelvi-peritonitis are situated behind or in front of the uterus, and usually determine fixation of the fundus and corpus, not of the cervix. It is, however, a matter of extreme difficulty to exclude pelvi-peritonitis involving the utero-sacral ligaments. Under these circumstances the history of the primary affection, and the condition of the tubes and ovaries, throw valuable light upon the diagnosis.

The residua of simple and septic phlegmons can be excluded by the history of the primary affection, and the character of the exudate, to which attention has already been called.

In diffuse chronic atrophic parametritis the vagina is narrow, and the anterior and posterior walls do not come into contact. The fornix is drawn out into a funnel-shaped cavity and is fixed. The vaginal walls are even, smooth, inelastic, thin, and covered with a sticky secretion. The whole organ seems to have undergone senile involution. The bladder and rectum jut out sharply into the lumen of the vagina. The supra-vaginal portion of the cervix is fixed by bands that radiate like cords in all directions through the parametrium. In the early stages of the disease the vaginal portion is in a state of chronic metritis, and profuse catarrhal secretions are poured forth through the os externum. Later the entire organ undergoes changes similar to those observed in senile atrophy.

The connective tissue of the parametrium is replaced by a dense, firm, and peculiarly sensitive cicatrix. The peripheral fatty connective tissue undergoes resorption, so that the interior of the pelvis is sharply outlined. The pelvic bones are painful, spontaneously and on pressure; hæmorrhoidal tumors, with or without the formation of rhagades, are visible around the meatus and anus.

Prognosis.—During the acute stage of pelvic cellulitis the prognosis should always be guarded. So long as the inflammation remains localized, as in simple phlegmon and the milder cases of septic phlegmon, the outlook *quoad vitam* is favorable.

When general infection from the local lesion in the genital tract occurs, the prognosis becomes doubtful. In the cases in which the septic poison gains access to the veins, it is always gloomy. Death, with or without the phenomena of thrombosis and embolism, is the usual termination within a variable period of a few hours or days.

The outlook is less unfavorable in cases in which the infectious inflammation extends by means of the connective tissue and lymphatic system. The process is slower and seems to be arrested, for a time at least, by the lymphatic glands, which are usually very much enlarged. In a word, the conditions for the battle of the cells with the bacteria are more favorable. Among the elements of prognosis in cases of systemic infection, the temperature, pulse, and degree of general prostration are the more important. Of these, the force and frequency of the heart's action are probably the most reliable index of the degree of systemic poisoning.

In attempting to make a prognosis with reference to the residua of pelvic cellulitis, it is necessary to bear in mind the natural history of the affection, and especially the terminations.

The tendency of the exudate of a simple inflammation of the pelvic connective tissue is to resorption, after a variable period. The resorption, however, is seldom complete, and, under the most favorable condition, the connective tissue is very infrequently restored to its normal relations. Functional and organic disturbances of the pelvic viscera are the usual sequelæ.

The occurrence of suppuration within the exudate is attended by consequences favorable and unfavorable. After abscess-formation and evacuation of pus, spontaneous cure frequently results when drainage is adequate, as in perforation of the vagina or above Poupart's ligament, and the cavity is not infected. Even when the quantity of pus evacuated is small, the circumscribing hard masses of exudate sometimes melt away under the process of resorption in a short space of time.

In the majority of cases of spontaneous evacuation, however, the cavity is insufficiently drained, a freely secreting pyogenic membrane is formed, and various untoward consequences are observed. The abscess-cavity may be infected by operative procedure, the diffusion of intestinal gases, or the entrance of fæcal matter—as in perforation of the sigmoid flexure or rectum. Ichorous changes occur, and the patient succumbs to septicæmia.

Perforation of the abscess-wall into the abdominal cavity is usually followed by a rapidly fatal general peritonitis—fortunately a very infrequent mode of termination.

The fact of the tuberculization of a pelvic abscess or of an old exudate that has undergone caseation or coagulation-necrosis has been abundantly demonstrated. The conditions for the extension of the tuberculosis, as before remarked, are now peculiarly favorable.

The woman may perish from exhaustion, consequent upon the hectic fever and continuous loss of pus, or from some intercurrent disease.

Then the effect of long-continued suppuration, in the causation of amyloid degeneration of the kidneys, liver, and other organs, is an element of great prognostic moment.

The prognosis in circumscribed chronic atrophic parametritis is favorable when the local irritation can be removed and the general nutrition can be improved. Pregnancy, as before remarked, exercises a most favorable influence, frequently resulting in the restoration of normal functional relations.

In diffuse chronic atrophic parametritis the prognosis is unfavorable as regards resolution, the nature of the process resembling that of cirrhosis of the liver, kidneys, and other organs. Freund has observed an arrest of symptoms, of long duration, under appropriate treatment, but has never seen a radical cure.

Treatment.—*Prophylactic.*—The prevention of pelvi-peritonitis and pelvic cellulitis, in view of the encouraging progress in exact knowledge of the causes, must be admitted to be possible in the very large majority of cases. Prophylaxis consists in the avoidance of every opportunity of infection. The general acceptation of the Semmelweis theory of puerperal fever is already beginning to limit the number of cases of septic infection during pregnancy, labor, and the puerperium. The same rigid antiseptic rules as those suggested by Semmelweis in the prevention of childbed fever must also be applied in all operations and manipulations in connection with the genital tract in the non-pregnant state.

Nelson,[23] of Chicago, makes a pertinent suggestion with reference to the prevention of gonorrhœal infection: "Should not competent physicians be employed to instruct the pupils in our public schools, of suitable age, in the proper use and abuse of the reproductive organs, including the evils resulting from self-abuse and the venereal diseases?" The examination of prostitutes at regular intervals, as practised, for example, in Vienna, has been only moderately successful in the prevention of gonorrhœa, although it does limit the spread of syphilis. This fact may possibly be due to the unfortunate legal restrictions to which the measure has been subjected.

Curative.—During the acute stages the indications for treatment are the prevention of further infection, the limitation of the local inflammation, and the allayment of symptoms as they arise.

The first indication, more fully discussed under the heading Puerperal Fever, deserves more than mere passing notice in connection with the therapy of pelvic peritonitis and cellulitis.

An important departure from older methods of routine treatment has been inaugurated, at a comparatively recent date, in Vienna, at the suggestion of Carl Braun.[24] After adequate recognition of the Semmelweis doctrine of puerperal fever, he says: "According to my experiences up to the present time, I hold the removal of the putrid tissue from out of the uterus by means of excochleation, thymol irrigation, and the introduction of iodoform as the best—and not dangerous—method of disinfection of the septically diseased puerperal uterus." The putrid tissue consists presumably of the retained portions of the placenta, membranes, and Friedländer's glandular layer of the decidua.

Good contraction of the uterus is an essential condition.

The indication for operative procedure is the existence of putrid tissue within the uterine cavity, and evidence of commencing infection—anomalies of temperature, pulse, and the like.

The patient is placed in the Sims position, or in the exaggerated lithotomy position, and curettement is practised with Sims' dull curette or Simon's spoon. The cavity of the uterus is irrigated with a solution of thymol (1 to 1,000). Thymol, according to Koch and Ranke (1878), stands next to mercuric chloride as a germicide, and the danger of toxæmia from resorption is minimal. Finally, a *bacillus* of iodoform is introduced into the cavity of the uterus for the purpose of continuous disinfection—*Dauerdesinfection*—obviating the necessity of frequently repeated intra-uterine irrigation.

The formulæ for the iodoform bacilli, as suggested by v. Mosetig-Moorhof in 1880, are:

I. Iodoform. pulv. 50.0
Amyli puri,
Gummi arabici pulv. .....āā 5.0
Aq. destill. q. s. ut f. bacilli, longitud., 8 ctm.; latitud., 4 mm.

II. Iodoform. pulv. 5.0
Amyli puri,
Gummi arabici pulv. ..... āā 6.0
Glycerin q. s. ut f. bacillus No. I., longitud., 6 ctm.; latitud., 1 ctm.

The large bacillus (No. II.) is usually employed. In the absence of the bacilli, iodoform gauze (v. Mosetig-Moorhof) or an emulsion of iodoform (H. Fritsch) may be used.

Although employed on a colossal scale in the obstetrical clinics of Vienna for a period of nearly seven years, not a single case of iodoform toxæmia has been observed. A short time since, Heyn and Rorsing,[25] of Copenhagen, published some experiments which seemed to prove that iodoform was inert in the presence of bacteria. Although such conclusions from experimental evidence are of slight value in the light of clinical experience, it is interesting to note the results of De Ruyter's[26] investigations. He found that the dry powder of iodoform outside of the body was not a germicide, but that when brought into contact with a freely secreting wound-surface it was at once decomposed and became powerfully antiseptic—the streptococcus pyogenes and the staphylococcus aureus seeming to be the cause of the chemical decomposition.

Under the conditions and indications already specified it is evident that curettement of the puerperal uterus is seldom necessary. In the very large majority of cases of puerperal septicæmia, the local lesion to which septic material gains access is situated somewhere between the cervix and the vulvar orifice, and, as remarked by Kucher,[27] "a well-contracted uterus is almost proof against infection." The mere presence of an offensive discharge is not, *per se*, an indication for excochleation. Credé puts the case clearly and forcibly when he says: "In Mecklenburg[28] the people say: 'A woman in childbed must stink herself out.' Let him who prefers a more elegant expression say: 'Nature must cleanse and evacuate the parturient passages of the puerperal woman, and during this process the odor of the puerperal woman is not agreeable.' This is an extremely simple process, similar to, but still easier and simpler than, the evacuation of the bowels, during which process the human being does not smell pleasantly, but yet is thoroughly healthy. The parturient passages have a more powerful musculature than the rectum, and wide-open excretory ducts, while the rectum must conquer and open the sphincter muscle of the anus. Even very foully smelling secretions do not poison, so long as their normal dejection is not disturbed."

The second indication is fulfilled by the institution of an energetic local antiphlogosis. Absolute rest in bed in the dorsal decubitus, the legs flexed upon the thighs and supported by pillows, until all acute symptoms have disappeared, is the first and most important regulation.

The local application of cold is an efficient remedy, especially in the acute stages of pelvi-peritonitis. Dry cold may be employed in the form of india-rubber bags or thin metallic boxes (Esmarch) containing ice. A more efficient mode of applying dry cold is that described by Petitgand under the name of mediate irrigation. A vulcanized india-rubber tube, sixteen or twenty feet long, and about half an inch thick, is coiled to fit the part, and held in position by a roller. Water, of any desired temperature, is caused to pass through this tube from a reservoir above the patient's level. Leiter, of Vienna, has constructed an ingenious modification of this apparatus, by the substitution of very flexible metallic tubing for the vulcanized india-rubber. The intensity of the cold is modified by the insertion of a towel or compress between the skin and the "heat-regulator."

Dry cold may be applied per vaginam, in accordance with Heitzmann's[29] suggestion. Thin metallic capsules, of variable size and shape, similar to Bozeman's hard rubber tampons for vaginal dilatation, are fitted with afferent and efferent tubes, and connected with suitable reservoirs.

Heat in conjunction with moisture, in the form of the hot-water douche, flaxseed meal, and hop poultices, is less efficient than cold in the limitation of the local inflammation during its initial stages, but is probably more extensively employed in America. Thus Emmet[30] advises the hot-water vaginal injections immediately after reaction, believing that "it is the only means we possess for aborting an attack of cellulitis—which *it will do*, if *thoroughly employed at the beginning*"—an opinion consistent with his peculiar views on the pathology of the condition, but opposed by our recent knowledge of causation and by the experience of other clinicians. We are informed by reliable authority, moreover, that Leiter's coils and cold water are almost exclusively employed, during the initial stages of pelvi-peritonitis and pelvic cellulitis, in the Woman's Hospital of New York.

The subject of local blood-letting has passed through a variety of phases of professional opinion, even in our own times. Scanzoni, Spiegelberg, and Schroeder recommend the application of leeches—ten to twelve—as near as possible to the focus of inflammation—inguinal region, perineum, or inner surface of the thigh. Ols-

hausen and Spiegelberg recommend very highly the application of leeches—four—to the vaginal portion early in the puerperium. Carl Braun,[23] on the other hand, never employs leeches until late in the puerperium, and only then after the failure of cold and narcotics to allay pain. The application is made to the inguinal region. In our own country, the practice has fallen into undeserved desuetude. Bandl is of the opinion that the pelvic pain is greatly lessened by adequate local bleeding, but is doubtful whether any important and lasting influence is exerted upon the local inflammation.

The alleviation of pain—a fact generally admitted—ought to constitute an indication in selected cases, even in the minds of those who do not believe with Ashhurst,[32] that "fatal disorganization in an important organ" may sometimes be prevented by sufficient local bleeding.

The employment of vesicants and counter irritants, generally, is reserved by common consent for the later stages of the affection.

Evacuations of the rectum at regular intervals must be secured. Not infrequently an accumulation of fæcal matter in the rectum, sigmoid flexure, or colon serves to aggravate the symptoms by pressure. Then Schroeder has pointed out the important fact that free intestinal peristalsis is of value in the prevention of the formation of adhesions to adjacent organs. Diarrhœa is not always an unfavorable sign, and it is well to consider carefully the conditions in the concrete case before remedies are exhibited to check the intestinal secretions. It is a well-known fact that dogs with peritonitis frequently recover after the occurrence of profuse, serous diarrhœa. Of course, allusion is now made to diarrhœa early in the course of the affection, and not to the colliquative alvine dejections which presage the lethal issue later in the course of the inflammation. Soft, semi-solid evacuations of the rectum are secured by enemata, castor-oil, or mild laxatives.

Under the third indication we have to consider, among other matters, the alleviation of pain, the reduction of temperature, and the sustenance of the vital powers.

Pelvic pain, measurably relieved by the therapy already suggested, demands the adequate exhibition of morphine hypodermatically, until the symptom is under control, when the effect of the drug may be maintained by suppositories containing the aqueous extract of opium. The administration of this drug per os should be avoided on account of interference with the functions of the alimentary canal. The distressing vesical symptoms, when not relieved by narcotics, may be alleviated by bland, mucilaginous drinks, and alkaline diuretics. Ten grains each of ammonium benzoate and sodium biborate, in a relatively large quantity of water, every six hours, is an efficient combination.

Formerly it was customary to regard pyrexia as the sign of chief prognostic moment, and treatment was addressed particularly to this symptom. Accordingly, quinine, sodium salicylate, antipyrin, and other members of the so-called coal-tar group, and digitalis, with or without the cold-water bath, constituted the basis of treatment. At the present time it is generally recognized that, when general infection has occurred, antipyretics have slight favorable influence in the battle of the cells with the bacteria, the chief reliance being placed upon food and stimulants. Thus Credé[33] remarks: "Medicaments (quinine, digitalis, and the like) are, indeed, generally employed to reduce the elevation of temperature and the acceleration of pulse, and I also in former years have often used them; but I am now thoroughly convinced that they exert not the slightest influence upon the septic process. It is much more rational and effective to come to the aid of the vital powers of the body, prostrated by the severe struggle against the germs, with appropriate roborants and stimulants—ether and camphor injected subcutaneously, wine and cognac exhibited per os." The line of treatment here indicated was ably discussed and fully approved at the first meeting of the German Gynecological Society, Munich, 1886.

Runge[34] advises as food: milk, strong meat soups and meat, cutlets, and beefsteak. Small quantities of peptonized milk at short intervals—forced feeding—are tolerated by the usually irritable stomach when other matters are rejected. The quantity of alcohol exhibited, of course, is purely relative. In one severe case of puerperal septicæmia, for example, Runge caused to be exhibited within six days ten and a half litres of wine and twenty-one of cognac. Rum, with or without egg-albumen and sugar, containing a relatively large quantity of alcohol (seventy-seven per cent.), is an eligible spirit. An excellent combination is that recommended by Buss (1878): 100 parts meat peptones, 300 parts grape sugar, 200 parts rum or cognac, the whole diluted with water.

One important obstacle to forced feeding and large doses of alcohol is the irritability of the stomach, as before remarked. This obstacle, however, is capable of being removed in the very large majority of cases by due care and thought as to the mode of exhibition.

After the subsidence of the symptoms of the acute stage, the object of the treatment is to secure, as far as possible, the resolution of the residua, adhesions, pseudo-membranes, exudates—the most favorable, natural termination of the inflammatory process.

Vaginal irrigation with hot water stands first, in point of efficiency, in the long list of local remedial procedures. The method of application and the physiological action are important topics for consideration.

The patient should be placed in the dorsal decubitus with elevated hips, or in the genu-pectoral position, as suggested by Emmet. The quantity of water to begin with should be at least half a gallon, and can be increased to three, or even four. The temperature of the water must be raised rapidly from blood-heat to 110° F., or to as high a degree as can be tolerated in the concrete case. Two irrigations per diem—at night before going to bed, and in the morning upon rising—are usually sufficient. Continuous vaginal irrigation with hot water through five, and even ten hours, has not yielded better results, in the hands of H. Fritsch and other observers, than the simple periodic douche as recommended by Emmet. The fountain syringe is in all respects the most eligible apparatus for purposes of irrigation. Emmet attaches considerable importance to the impulse of the jet of Davidson's syringe in the excitation of the proper contraction of the vessels. This effect is largely imaginary, entirely apart from the consideration that comparatively few patients are in a position to command the services of a nurse. It is utterly impossible for the patient herself to use the Davidson syringe under the conditions already specified; and as Emmet[35] says, "unless the details can be carried out fully, the process only involves a waste of time and a tax on the strength of the patient."

The action of the hot water seems to be largely concentrated upon the blood-vessels, although doubtless the succulency of the parts is increased by osmosis. The conclusions derived from the experiments of R. Milne Murray[36] are of interest in this connection. They are:

1. Water at temperatures of 120° F. and 10 degrees lower, constricts blood-vessels and arrests hæmorrhage from small arteries.

2. Water at temperatures of 100° F. and 30 or 40 degrees under, dilates small vessels and promotes hæmorrhage.

3. Water at temperatures of 50° F. and 20 degrees under, checks hæmorrhage by constricting blood vessels, but this only temporarily.

4. After water at the above temperatures has lost its styptic power, water at high temperatures is still effective.

Moisture in connection with warmth, in the form of the so-called Priessnitz fomentations, is a deservedly popular remedy in Germany. A towel, wrung out of lukewarm or cold water, is applied to the hypogastric region, covered in with oiled silk or a woollen cloth, and allowed to remain in place during the night, or longer. The water may be medicated, if desired, with ammonium chloride, potassium iodide, or narcotics. This method of hydrotherapy, introduced by a Bavarian peasant, is quite innocuous, and has a very positive effect in the alleviation of pain, if not in the hastening of resorption.

Sitz-baths in plain or medicated, warm or hot, water, combined with energetic rubbing of the pelvic extremity, induce circulatory changes in the pelvis of importance in the relief of pain, and resorption of the exudate.

The topical use of alteratives in general, and of iodine in particular, constitutes a most important part of the treatment. The same remedies exhibited per os are not followed by the same favorable changes in the exudates. Churchill's tincture of iodine, applied to the vault of the vagina and inguinal regions; iodoform, iodol, oleate of mercury, exhibited per vaginam through the media of vaseline, gelatine, and cacao butter, in connection with the glycerine tamponade, are of great value as sorbefacients. Scanzoni[37] recommends the introduction into the vagina of small sponges saturated with a solution of potassium iodide, 4.0; in glycerin, 30.0. Thomas prefers Greenhalgh's iodized cotton. Two hundred and fifty grammes of absorbent cotton are saturated in a mixture of potassium iodide, 60.0; iodine, 30.0; and glycerin, 250.0, and are then carefully dried. Chrobak employs potassium iodide thoroughly incorporated in gelatine. The chief objection to this drug is its intensely irritant local effect.

The enormous blisters, so warmly recommended by Bernutz and Courty, even during the acute stage, are no longer used; still, small flying blisters to the inguinal regions relieve pain consequent upon the stretching of adhesions, and aid materially in the process of resolution.

The Thur-Brandt[38] system of uterine gymnastics—massage—has a limited field of application in selected cases that have resisted less heroic methods of treatment. One of the essential conditions of this procedure is the complete disappearance of all acute inflammatory symptoms.

Much has been expected of electrolysis and di-electrolysis in the resolution of pelvic exudates. A careful analysis of the cases, in which the diagnosis was clear, reported up to the present time, yields only evidence of a negative character. The subject, however, is in its infancy, and it is not unreasonable to await with great hope the developments of the near future. The discussion of the conditions, indications, and methods under which electricity should be employed would be obviously premature, and entirely beyond the limits of this paper.

In the circumscribed form of chronic atrophic parametritis, attention to the local lesion of the bladder, rectum, or uterus, fulfils the most important indication for treatment. In the diffuse form of the affection Schroeder has obtained the best results from vaginal irrigation with hot water, sitz-baths, general and local massage, and the administration of tonics. Freund raises a voice of warning against castration in these cases of hysteria. Bismuth subnitrate is of value in the group of sympathetic reflex neuroses, argentic nitrate in spinal neuroses, and acetate of zinc in those of cerebral origin.

The general or constitutional treatment, a subject of vital importance, cannot be adequately discussed in the space at our command. Mention, however, must be made of the advantages derivable from a prolonged sojourn at one of the various watering-places and baths, a mode of cure to which European clinicians justly attach great value. The rigid observance of hygienic rules, the imbibition of enormous quantities of water more or less impregnated with various salts and carbonic acid, the frequent baths, exercise, and recreation often produce changes in the local condition which are little less than marvellous. The plan of general treatment is essentially tonic in character, and includes attention to hygienic relations, the exhibition of chalybeates, cod-liver oil, and the like. The views of S. Weir Mitchell[39] and Goodell[40] on the subjection of nutrition, fully detailed in other portions of this work, deserve especial consideration in connection with this subject.

Operative Treatment.—The residua of pelvi-peritonitis seldom demand operative interference, apart from the rare phenomenon of intestinal constriction or strangulation by pseudo-membranes. On the other hand, however, symptoms referable to the tubes and ovaries, especially in cases of gonorrhœal salpingitis and ovaritis, frequently indicate the performance of Tait's operation for the removal of the uterine appendages by abdominal section. Under these conditions, after the excision of the tubes and ovaries—usually foci of infection—the pelvi-peritonitis may terminate in resolution, as in the thirty-five cases cited by A. Martin.[41] The same statement holds true with reference to the tuberculous and actino-mycotic forms of the disease.

Opinions differ widely as to the indications for operative interference after the occurrence of suppuration or abscess-formation within the exudate. All the diagnostic penetration of the physician and a high exercise of judgment are necessary to determine when to preserve a wise and masterly inactivity, and when to adopt measures of active interference. The mere presence of pus within the exudate, in the absence of constitutional symptoms, is not necessarily an indication for artificial evacuation. Suppuration usually begins, as before remarked, in small multiple disseminated foci, surrounded by hard masses of exudate. It is difficult, sometimes impossible, under these conditions to find the pus-cavity without doing serious injury to the adjacent tissues and organs. Then the amount of pus capable of liberation by a single puncture or incision is insignificant.

Another important point for consideration is the fact that exudates which have been transformed, in part or entirely, into pus frequently undergo complete resorption.

On the other hand, it is necessary to bear in mind the fact that the diagnosis of pelvic abscess is sometimes difficult. The local and general symptoms may be very obscure. Fever, rigors, and night-sweats may be absent throughout the course of the affection, as in two of the cases cited by Fenger. Then there is danger in waiting too long, on account of the effect of prolonged suppuration in the causation of amyloid degeneration of the kidneys, liver, and other important viscera.

Of course, when the sensitive exudate tumor gradually increases in size, and exacerbations of fever, rigors, and night-sweats are present, the indication for operative interference is perfectly plain. It is better, under these conditions, when the pus is near the surface, to select the site for the escape of pus than to await pointing and spontaneous evacuation, through a possibly unfavorable channel.

As to methods of operation, there are a number of procedures to be considered. If the abscess points through the fossa of Douglas, vaginal incision is obviously the operation of election. As performed by Schroeder, this operation consists in the incision of the posterior vaginal fornix, perforation of the abscess-wall with the finger, evacuation of the pus, curettement or scraping of the cavity (if indicated by the presence of a pyogenic membrane), irrigation, packing with iodoform, and vaginal drainage. This operation, however, is not free from objections. It is difficult to maintain aseptic drainage. If the abscess is situated high up in the pelvic cavity, the sac can be reached only after considerable exertion, and there is great danger of wounding a large vessel—difficult or impossible to ligate—of injuring the ureters, or of passing into the peritoneal cavity or the rectum.

If the abscess points along Poupart's ligament, incision may be made along this anatomical boundary with reasonable hope of completely evacuating the pus-cavity. The abscess-cavity is usually separated from the peritoneum by a considerable distance, and the operation is fraught with but little danger. As remarked by Fenger,[42] "The operation is simply an oncotomy, and does not differ materially from the opening of a deep-seated abscess in any other region of the body, *e.g.*, in an extremity."

Hegar[43] recommends, in order to evacuate deep-seated parametritic abscesses at an early period, incision along Poupart's ligament, separation of the peritoneum, and the boring down with the finger between the bladder and the horizontal ramus of the pubes until the base of the broad ligament is reached. Hegar sometimes reaches abscesses, similarly situated, by incision into the ischio-rectal fossa, and boring upward with the finger.

Abscesses opening through the abdominal parietes, for

example in the vicinity of the navel usually, though not necessarily, of intra-peritoneal origin—and communicating with circumscribed collections of pus in the fossa of Douglas, may be advantageously drained in many cases by a tube inserted at the umbilical ring, and passing out through the vagina, as practised by Hegar.

There still remains a large class of abscesses that cannot be advantageously treated by any of the methods already detailed. Many of these cases indicate laparotomy. "The treatment of suppuration within the pelvic cavity by abdominal section and drainage we owe to Mr. Lawson Tait."[44]

Tait's operation consists essentially in abdominal section, incision of the abscess wall with the evacuation of the pus through the abdominal opening, scraping of the lining membrane if necessary, stitching the artificial mouth of the abscess to the edges of the abdominal incision, and drainage through the cut in the abdomen. Tait's operation is free from the objections urged against the vaginal operation when the abscess is high up in the pelvis, or above the inlet, and, moreover, enables the operator to gain free access to the whole interior of the abscess cavity, as well as to the contents of the pelvis.[45]

Up to 1886 Tait had performed thirty-two operations for pelvic abscess, in every one of which a cure had resulted.

About one year ago Mikulicz, of Cracow, proposed a method of drainage for cases of peritonitis that renders Tait's operation more complete. As described by Fenger,[46] who has used the plan in cases of retro-peritoneal cysts, Mikulicz's method of drainage is as follows: He takes a small piece of iodoform gauze, stitches a silk thread to the centre of it, and folds it up in the form of a pouch, the silk thread being inside, that the pouch may be drawn up from the bottom by it. The pouch is now pushed down to the bottom of the cavity, and if nooks and corners exist, it is pushed out so as to completely fill them. In the inside of the pouch iodoform gauze is packed, as much as is necessary to completely fill up these spaces.

As soon as the discharge ceases the loose gauze is gradually pulled from inside the sac until it is emptied. The period of time through which the drain is allowed to remain is indefinite. Fenger has allowed it to remain as long as two weeks.

The advantages claimed for this method, as compared with the use of glass or rubber drainage, are:

1. The cavity of the abscess is kept continuously disinfected by the iodoform gauze, which fits snugly into every nook and corner.

2. By the capillary attraction of the gauze, fluids that a glass or rubber drain would not affect are brought out of the cavity.

Fenger supplements the Mikulicz drain by a glass or rubber tube inserted in the centre of the gauze.

But the abscess may be so located, the walls so fragile or so bound to adjacent tissues and organs, that the artificial mouth cannot be united to the edges of the abdominal incision. Under these conditions Martin's[47] operation for extra-peritoneal hæmatoma comes up for consideration. Martin's operation consists in laparotomy, eventration when necessary, incision of the abscess-sac, evacuation of the pus, curettement, irrigation of the cavity, continuous disinfection with iodoform, drainage per vaginam, closure of the incision into the sac and through the abdominal parietes. This operation has yielded favorable results in six cases of extra-peritoneal hæmatoma in Martin's hands.

In cases in which the abscess has already opened into one of the hollow viscera with inadequate drainage, it may be advisable to enlarge the opening, scrape and disinfect the interior, and attempt drainage through the channel formed by the spontaneous evacuation. Thus Schroeder, in two cases of pelvic abscess opening into the bladder, performed the *sectio alta*, drained the abscesses, and effected cures. W. H. Byford, among others, advises dilatation of the anal sphincters, enlargement of the primary opening into the rectum, and drainage through this viscus. The dangers of infection from the diffusion of gases, and the access of fecal matter, as well as the difficulty in maintaining drainage, strongly condemn this method as a primary choice, and render extremely problematical its value even after spontaneous evacuation of the abscess into the rectum.

W. W. Jaggard.

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PELVIPERITONITIS. ETIOLOGY AND PATHOLOGY.—Pelviperitonitis is one of the most frequent symptoms of the diseases of the female sexual apparatus. Beigel[1] observed traces of perimetritic inflammation in over ninety per centum of the cases in 600 autopsies. Bandl[2] found the residua of circumscribed peritonitis in more than half of all female cadavers; Winckel,[3] in more than thirty-three per centum; A. Martin,[4] in 122 out of 287 cases of tubal disease.

For the purpose of discussion, pelviperitonitis may be considered as (I.) benignant—non-infectious—and (II.) infectious.

I. BENIGNANT PELVIPERITONITIS.—The potential etiological factors of non-infectious pelviperitonitis include in the first line the sexual life in all its phases, to use one of Schroeder's happy expressions. Menstruation, onanism, cohabitation, labor, and the like, effect certain changes in the uterus, tubes, and ovaries, which may lead to the implication in the inflammatory process of the corresponding areas of the pelvic serosa. An infectious inflammation of the mucous membrane of the tube may cause a non-infectious inflammation of the tubal wall, and this may in turn be attended by a benignant perisalpingitis, periöophoritis, or perimetritis. As remarked by Sänger:[5]

"A specific gonorrhœal inflammation of the mucous membrane of the tube, with secretion of pus into the cavity of the latter, is accompanied by a non-specific inflammation of the entire tubal wall. This may also excite perisalpingitis, perioöphoritis, and so forth; the organs involved may become adherent to each other and displaced, but we never meet with a purulent exudate of the same nature as that found in the cavity of the tube itself." In tuberculosis of the pelvic genitalia the same benignant pelviperitonitis is observed. Displacements of the uterus and adnexa—retroversion and retroflexion, with prolapse of one or both ovaries, in particular—lead to local hyperæmia and the formation of adhesions to the adjacent pelvic peritoneum. Tumors in connection with the pelvic viscera—benign and malignant—are attended invariably by attacks of peritonitis, which tend to incapsulate the neoplasmata. Recurrent attacks of pelvic peritonitis are especially frequent in cases of ovarian and parovarian cystomata from the rupture of single cysts and the escape of their contents into the abdominal cavity.

The dysenteries of childhood are important factors in the causation of attacks of pelviperitonitis that are discovered about the time of puberty.

Parametritis may give the primary impulse to a benignant pelviperitonitis, instead of the connective tissue being itself secondarily involved, which is usually the case. Finally, we have in the ruptured cyst of ectopic gestation and pelvic hæmatocele two very important causative agents.

Benignant pelviperitonitis is usually localized, partial, and essentially chronic in its course. In cases of the rupture of the sac of extra-uterine pregnancy, and of single cysts in ovarian and parovarian cystomata, the inflammatory process may involve the serosa of the abdominal cavity and become general. According as the peritoneal covering of the uterus, tubes—the fimbriated extremities in particular—the ovaries, the bladder, or the rectum, is the region especially affected, it is customary to speak of a perimetritis, a perisalpingitis, a perioöphoritis, a pericystitis, and a periproctitis.

The *anatomical findings* consist in thickening of the peritoneum, deposits of stratified lymph, adhesions, and pseudo-membranes binding the pelvic viscera together, in extreme cases, into an indivisible mass. The sacro-uterine ligaments—sometimes called the *musculi retractores uteri*, on account of the traces of non-striated muscular tissue contained—are especially liable and apt to undergo cicatricial contraction and cause lateral or retro-displacements, according as one or both are affected. Cavities formed by the agglutination of the pelvic viscera by adhesions and pseudo-membranes, and filled with a serous exudation, may give origin to pseudo-cysts of considerable size. Pyocele, however, is an infrequent condition.

II. Infectious Pelviperitonitis.—Infectious pelviperitonitis, as might be inferred from *à priori* considerations, is of much more frequent occurrence and of vastly greater clinical significance than the benignant form of the affection. It is fair to assume that there are as many varieties of infectious pelviperitonitis as there are varieties of infectious inflammation of the tubes. The pelvic peritoneum is open to the secretions of the tubal mucous membrane, to the air and the germs suspended in it, through the ostium tubæ abdominale, and is exposed to carriers of infection coming from the abdominal cavity and its contained organs. Then, septic germs, in particular, may gain access to it through the pelvic connective tissue.

Sänger's[6] classification of salpingitis, which is the most complete, and the most in accord with the present state of our knowledge of the laws governing the inflammatory process in other regions of the body, constitutes the basis of the following brief account.

1. *Septic Pelviperitonitis.*—In this group are included all those forms of pelviperitonitis which are "due to specific microbes identical with those producing traumatic infection"—*i.e.*, septicæmia, pyæmia, sapræmia, diphtheria, phlegmon, erysipelas. All the micro-organisms producing these different kinds of traumatic infection have not been isolated and classified, but the streptococcus pyogenes of Rosenbach and the staphylococcus aureus and albus are probably among the most important. Two conditions are essential to the production of septic pelviperitonitis—a local lesion of the genital tract, and its infection. Parturition and operative procedure are the two important factors in the fulfilment of these conditions. The greater number of cases and the more serious cases occur after parturition, but their discussion is foreign to the object of this paper. But in operative procedure, however apparently trivial in character, we have a factor the significance of which is apt to be overlooked. The unskilful use of the sound may produce a lesion of the mucous membrane, or even of the muscular tissue—as in the so-called catheterization of the tubes—and, at the same time, if the instrument is unclean in the surgical sense, may infect the wound. The danger of the infection of a wound-surface is obviously greater in curettement.

Emmet's operation upon the vaginal portion, as it is usually performed in our country with insufficient antiseptic precautions, frequently stands in a causal relation to septic pelviperitonitis. In the event of infection of some local lesion in the genital tract the inflammation reaches the peritoneum by continuity of tissue through the uterus and tubes, or the microbes penetrate the pelvic connective tissue and lymph-spaces and gain access to the serosa through the lymphatics.

The clinical picture is the resultant of two factors—the local lesion in the genital tract, and the constitutional effect of the infection through the medium of the circulation, the latter being by far the more important of the two. The development of the disease is accordingly rapid; its course acute and malignant. The marked pathological characteristic of the local lesion is the tendency toward the involvement of all the tissues of the pelvic viscera in a process of destructive suppuration.

The *anatomical changes* of greatest importance to the gynecologist are in connection with the exudates. Following the primary injection of the blood-vessels, and loosening of the serosa, an exudation occurs. This exudate—serous, hæmorrhagic, or purulent, containing large numbers of micrococci—collects in the fossa of Douglas, and, overflowing, fills up the available space in the pelvic peritoneal cavity. Incapsulation speedily results; the movable pelvic viscera, coils of intestine, and omentum are bound together by adhesions and pseudo-membranes in such a manner as to shut off communication between the exudate and the abdominal cavity. The exudative process continuing, the retro-uterine tumor grows larger, its walls more tense, and it acquires many of the physical characters of retro-uterine hæmatocele.

The terminations of the exudate are obviously significant. Serous and hæmorrhagic exudates frequently disappear by resorption within a short time after their production. It will be remembered that the capability of resorption by the peritoneum is greatly increased by the inflammatory process. Serous and hæmorrhagic exudates are accordingly seldom seen in autopsies, except in cases of general peritonitis.

The fate of purulent exudates depends largely upon the quantity and quality of the pus. When the exudate is small, the pus may undergo fatty degeneration and be resorbed, as demonstrated by Klob. If the quantity of pus be large, and particularly if it has undergone ichorous changes, the sac ruptures into one of the hollow viscera, through the abdominal parietes, or into the abdominal cavity, with fatal termination as a rule. The colon, the upper portion of the rectum above the sphincter tertius, and the anterior abdominal wall in the region of the navel are the regions of election for escape of the pus. The sigmoid flexure, vagina, bladder, and uterus are less frequently involved. Spontaneous cures, under these conditions, are infrequent, except in case of the evacuation of the pus through the vagina, since the pus-cavity is seldom adequately drained; periodic discharges from the cavity of the abscess through the corresponding hollow viscus are usually observed.

Finally, even in case of a relatively large purulent exudate the fluid elements may undergo resorption, while the remainder may persist for years in its capsule in a state of cascation or coagulation necrosis.

The pathogenous bacteria apparently perish soon after the incapsulation of the exudate and the formation of a pyogenic membrane lining the interior of the sac, so that a revival of the septic process is infrequent. In this important respect, septic pelviperitonitis differs essentially from the gonorrhœal form of the affection. The exudate, however, acts as a constant irritant, involving the adjacent tissues in a benign peritonitis, which finds its expression in a continuous proliferation of connective tissue.

2. *Gonorrhœal Pelviperitonitis.*—Noggerath (1872) announced that gonorrhœa in the male is incurable; that in the cases of so-called cure, the disease is merely latent; that the wife is invariably infected; and that among the manifestations of latent gonorrhœa in the female are: (1) Acute perimetritis, (2) recurrent perimetritis, (3) chronic perimetritis, (4) ovaritis. Assuming, with Ricord and Uhzmann, that eighty per cent. of the male population acquire gonorrhœa, he believes that almost all married women are infected. These revolutionary views were matured by clinical observation long before the discovery of the gonococcus of Neisser (1879). The results of more recent investigation go far toward strengthening Nöggerath's position, although opinions differ still as to the relative frequency of the condition. Thus Schroeder's remarks, "According to my experience, male clap can indeed have all these evil results, but by no means does it have them regularly." "The recognition," says Sänger, "of the active, etiological relation of severe disease of the sexual organs with gonorrhœa, by Nöggerath, constitutes an achievement for gynecology scarcely less than that of Semmelweis for obstetrics." Sänger (1884) estimates that one-ninth of all gynecological cases are due to gonorrhœa; that about half the number of infected women suffer from implication of the adnexa. At a later date (1886), he reports 230 out of a total of 1,930 gynecological cases (polyclinic and private practice)—twelve per cent., one-eighth of all cases—caused by gonorrhœa. Moreover, he is of the opinion that many cases of puerperal disease, erroneously ascribed to septic poisoning, are in reality cases of gonorrhœal infection; finally, that gonorrhœal infection constitutes by far the most important and most frequent etiological factor in the severer diseases of the uterine appendages. On the other hand, out of 287 cases of tubal disease reported by A. Martin, 75 stood in demonstrable causal nexus with the puerperium, while 55 were due to gonorrhœa. Martin, accordingly, is inclined to the belief that the puerperal-septic form of the affection is of most frequent occurrence and of greatest clinical significance.

The development of the disease is insidious, and its course extraordinarily chronic. The inflammation persists as a disease of the surfaces of the mucous and serous membranes, in sharp contrast with septic infections. Recidiva are constant. Gonorrhœal pus, accumulating in the tubes until discharged through the ostium tubæ abdominale into the pelvic peritoneal cavity, as the result of hyper-distention, trauma, violent exertion as in labor, and the like, gives origin to acute exacerbations, resembling in the suddenness, severity, and violence of the symptoms a peritonitis following perforation. The gonococci, or the active agent of infection, seem to be very much more tenacious of life than the micro-organisms peculiar to the septic process.

3. *Tuberculous Pelviperitonitis.*—Genital tuberculosis may be primary or secondary. The primary form of the disease is of chief interest to the gynecologist. The fact of its occurrence has been established. Rokitansky, many years ago, asserted that tubal tuberculosis was usually a primary affection. Czerny observed during a laparotomy primary tuberculous peritonitis, having its origin in the genital tract, and removed the diseased tubes. Hegar[7] has recently collected the literature of the subject and the cases coming under his own observation in a monograph, from which most of the following statements are drawn.

It is impossible, at the present time, to make an exact estimate as to the relative frequency of primary genital tuberculosis. Out of 96 autopsies on tuberculous cadavers, Frerichs found the genital tract involved in 16 cases, of which 3 were regarded as primary affections. Mosler, out of 48 cases of genital tuberculosis, found 8 regarded as primary. On the other hand, Schramm has collected 34 cases, only one of which he regarded as primary; Martin, out of 287 cases of tubal disease, found 10 due to tuberculosis, not one case primary.

The infection of the genital tract by the bacillus tuberculosis (Koch) may proceed from the patient's own body, or the germs may be introduced from without. Sputum from a tuberculous lung, faeces from an ulcerated intestine (Weigert, Klob), may gain access to the vagina of the same individual, and act as carriers of infection. Intestinal tuberculosis, involving the abdominal peritoneum and propagated through the subserosa and lymphatics to the genital tract and the blood, as in tuberculosis of the brain, bones, and prostate, are the more usual modes of auto-infection. Cases of hetero-infection are not infrequent. The examining finger, surgical instruments, especially during pregnancy, labor, and the puerperium, may carry infectious matter. Salleron, Fernet, Verneuil, and others have demonstrated that tuberculous infection may result from coition.

The course of genital tuberculosis is usually chronic. In exceptional cases the course is acute, especially when infection occurs during the puerperal state. Rokitansky cites a case in which death occurred nineteen days after labor; Wernich, one in which death occurred thirty-three days after labor. Under these circumstances, the lethal issue is frequently caused by general peritonitis.

The *structural changes* are fully described in other portions of this work. The spontaneous healing of circumscribed, and even of diffuse, tuberculous peritonitis, has been abundantly demonstrated, although such a favorable termination must be regarded as exceptional. In these cases the tuberculous deposit is incapsulated in dense, callous, cicatricial connective tissue, which causes the blood-vessels to undergo thrombosis, while the lymphatics are obliterated.

4. *Syphilitic Pelviperitonitis.*—Bouchard[8] and Lépine have observed and described cases of tubal syphilis in which the pelvic peritoneum was also involved. A. Martin[10] observed three cases of tubal disease in patients in whom recent syphilitic manifestations were present; it was established that traces of recent syphilis were present at the time that the symptoms, due to disease of the tubes, first appeared. Wylie,[11] of New York, is of the opinion that syphilis may cause salpingitis, just as it does otitis or ozæna. Too little is known of this form of pelviperitonitis to justify the formulation of dogmatic propositions.

In the cases of Bouchard and Lépine both tubes were swollen, and the mucosa revealed the characteristic lesions of gummatous inflammation; three gummata of the size of hazel-nuts were present.

5. *Actino-mycotic Pelviperitonitis.*—Zemann[12] has demonstrated the occurrence of pelviperitonitis and tubal disease as the result of infection by the actinomyces bovis (Bollinger). The tubes in this case were dilated and filled with pus and clumps of the actinomyces, their walls were thickened and exhibited numerous granulations produced by the fungus. Hochenegg[13] reports a case of primary abdominal actino-mycosis, occurring in a man, in which infection occurred from the intestine. The patient received a blow upon the abdomen, and adhesive peritonitis with the formation of a callosity resulted; the intestine was probably injured and the fungus escaped into the abdominal cavity. Infection, however, may occur from the vagina.

The course of the affection is chronic, and all cases reported up to the present time, in which operative procedure was not resorted to, have terminated fatally.

6. *Mixed Infectious Pelviperitonitis.*—Of the varieties of so-called mixed infectious pelviperitonitis, the combination of the septic with the gonorrhœal forms is of chief clinical significance.

Gonorrhœa invades the genital tract with especial rapidity during the period of involution. A gonorrhœal pelviperitonitis is frequently superinduced upon a puerperal parametritis. Tuberculosis following septic or gonorrhœal infection is not infrequent. The tuberculization of an old exudate was recognized by the old Vienna school as a natural termination. Bernutz speaks of the tuberculization of a gonorrhœal or puerperal pelviperitonitis. In many of these cases, however, the pus simply underwent caseation—coagulation-necrosis, according to Cohnheim and Weigert—and not tuberculization. We know now, since the discovery of the bacillus tuberculosis of Koch, that tuberculization does not occur without a tuberculous infection. Teierlink and Birch-Hirschfeld report a case of caseous epididymitis in consequence of gonorrhœa; general tuberculosis followed, and the patient died on the ninth day.

Symptoms and Diagnosis.—The inflammatory affections of the pelvic organs, as remarked by Bandl,[14] have very many symptoms in common in the beginning, and it is only in the later course of the process, when objective palpable changes are added to the subjective signs, that the involvement of a particular organ or tissue can be definitely ascertained. The symptoms, of course, will depend very largely upon the nature and intensity of the causative agent.

In *benign pelviperitonitis* the symptoms are of a local character and relatively insignificant. The inflammation frequently runs its course without seriously attracting the patient's attention.

The *diagnosis* is usually made from the results of the process. Pain, dull and gnawing, or sharp and lancinating, caused by the stretching of adhesions or by a new circumscribed inflammation, may be constant, or, more usually, is perceived at periodic intervals, as during defecation and the menstrual epoch. Vaginal examination reveals displacements of the uterus, tubes, ovaries, and broad ligaments, conditioned upon cicatricial contraction of the adhesions and pseudo-membranes. The presence of an exudate in the fossa of Douglas is an inconstant phenomenon.

In *septic pelviperitonitis*, sudden and acute pain, referred to the hypogastric region, is probably the first symptom to attract the patient's attention. Sensations of chilliness, or a well-pronounced rigor, with a continuous fever of high grade; nightly exacerbations; small, irregular, and extraordinarily frequent pulse, and marked general prostration follow. Meteorism, at first confined to the hypogastric region and becoming general when the peritonitis is diffuse, dyspnœa, nausea, retching, vomiting—in fatal cases, collapse—are among the classical signs. The patient elects the dorsal decubitus, and flexes the legs upon the thighs to relax the tension of the abdominal walls. She complains of thirst and loss of sleep, and is uncontrollably restless; exceptionally, a condition of euphoria may obtain, and she may pass into coma and collapse without one distressing symptom. Constipation is the rule, and profuse diarrhœa infrequent. Vesical tenesmus is a troublesome and constant symptom. The enlargement of the spleen is usually so marked that Carl Braun[15] regards it as one of the pathognomonic signs.

The residua more particularly concern the gynecologist, from a diagnostic point of view. Of these the more important are the exudates and pseudo-membranes. The symptoms due to the incapsulated exudate will depend upon its position, size, and the nature of its contents. Vaginal examination, rendered difficult by the tension and tenderness of the abdominal walls, reveals an œdematous state of the vaginal vault—occasionally hot and dry, from deficiency of normal secretions—and pulsation of the vaginal arteries. The exudate being almost always retro-uterine, the posterior fornix is distended, convex downward, yielding the sensation of elastic resistance, becoming firmer with the incapsulation and partial resorption of the fluid elements. The increased sensibility of the parts is manifest, the slightest touch evoking cries of pain. The introduction of the index-finger into the rectum is of service in determining the size, location, and consistency of the exudate.

The commencement of suppuration within the exudate is indicated by changes in its consistence, softening, fluctuation, and the well-known constitutional phenomena. The fact of rupture into the rectum or elsewhere is usually easily determinable, although it is difficult, if not impossible, to detect the exact site of perforation, since the aperture is small, and its walls are approximated after the discharge of the pus.

As before remarked, healing of the abscess-cavity, after spontaneous evacuation of its contents, is incomplete, except in those favorable cases in which the vagina is perforated and adequate drainage is effected. Fever of a remittent type, with evening exacerbations, is constant. The elevation of bodily temperature is measurably proportionate to the rapidity of resorption, and is not always a sign of unfavorable prognostic moment.

Of the dislocations of the uterus, tubes, and ovaries, caused by the pseudo-membranes, adhesions, and cicatricial contraction of the broad ligaments, posterior and lateral displacements into the fossa of Douglas are of most frequent occurrence and of chief clinical import. The contracting pseudo-membranes may occlude the tubes or completely cover the ovaries, so that sterility is a very usual consequence of all forms of pelviperitonitis in cases in which it has not already been conditioned upon antecedent disease of the tubes and ovaries. When pregnancy does occur, the adhesions usually undergo a species of evolution, and yield as the uterus passes into the abdominal cavity. In other cases, however, the uterus remains immobile, symptoms of incarceration follow, which may indicate the evacuation of the uterine contents. Dyspareunia is a constant and distressing symptom.

The symptoms of *gonorrhœal pelviperitonitis*, dependent in great part upon the nature of the infection, whether recent or chronic, are rendered obscure in the beginning of the attack by the antecedent inflammation of the vaginal mucosa, endometrium, and tubes.

The diagnosis rests upon the demonstration of the specific pyosalpinx, endometritis, kolpitis, including the affections of the vulvo-vaginal glands and urethra, history of the case, and confrontation of the man. The demonstration of the presence of the gonococcus of Neisser is not essential to a positive recognition of the nature of the case.

The diagnosis of *tubercular pelviperitonitis* is involved in many difficulties, and is based upon changes in connection with the tubes and adjacent organs rather than upon symptoms referable to the pelvic serosa. The nodules, cheesy masses, and ulcers are usually sufficient to indicate the implication of the vagina and vaginal portion of the cervix. In the first stage of tuberculosis of the tubes and peritoneum, according to Hegar, when the different structures can be isolated, the median and interstitial sections of the tubes are the sites of tubercular deposits simulating small fibromata; in pyosalpinx from other infections, they are free from circumscribed enlargements.

The tubes do not present the curved, ovoid, smooth surface peculiar to pyosalpinx of gonorrhœal origin, for example, but are irregular, polygonal, and rough in outline. Circumscribed tubercular nodules may be felt, under favorable conditions, on the broad and sacro-uterine ligaments, and on the peritoneum covering the posterior uterine wall. The hypogastric lymphatic glands are enlarged and the vessels may occasionally be felt pursuing their tortuous courses. The consistence of the tubercular nodules is peculiar, and harder than that of simple imflammatory deposits. In general, however, it must be admitted that there is little of a characteristic nature in the form, size, and position of the uterine adnexa, in genital tuberculosis, upon which a positive diagnosis can be established.

In the second stage, when the pelvic viscera are so covered and bound together by exudates as to be no longer separable by the examining finger, the obscurity with reference to diagnosis becomes greater. Still, even under these circumstances, the tubercular nodules in the pelvic peritoneum, the enlarged lymphatic glands and vessels,

the transudates, the anæmnesis, the hereditary relations, the opportunities for infection, the course of the disease, and the condition of other organs, frequently lead to the recognition of the condition. The microscopical examination of the discharges not infrequently throws much light upon the case.

The diagnosis of *actino-mycotic pelviperitonitis* depends upon the recognition of the fungus, usually present in the purulent discharges.

Prognosis.—The prognosis in pelvic peritonitis is always serious. As remarked by Heitzmann,[1] it assumes an extraordinarily varied form, according to the individuality of the special case, the nature, degree, extent of the inflammation, and the complications. In general terms the outlook, so far as life is concerned, is favorable when the inflammation is localized, the exudate incapsulated—shut off from the abdominal cavity—the neighboring organs not gravely involved, and the constitution of the individual not profoundly debilitated. Septic, tuberculous, actino-mycotic pelviperitonitis, however, may become of the initial lesions of general infection with lethal issue.

While the mortality is relatively small, the morbidity, with all the innumerable ills which may render the patient a life-long invalid, is very great. The residua—the displacements of the uterus, tubes, and ovaries, implying dysmenorrhœa, dyspareunia, sterility, interference with the functions of the rectum and bladder—are a prolific cause of prolonged invalidism, which in many cases is not preferable to death.

Then it must be borne in mind that while a purulent exudate is usually evacuated externally, it may rupture into the abdominal cavity and excite fatal peritonitis. The spontaneous drainage of an abscess-cavity is seldom sufficient, and the prolonged suppuration causes important degenerative changes in the glandular system, particularly in the kidneys, liver, and spleen. Finally, the caseation of an exudate presents a favorable nidus for tubercular infection.

(For Treatment see under Pelvic Cellulitis.)

W. W. Jaggard.

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[3] Lehrbuch der Frauenkrankheiten, p. 713. Leipzig, 1886.

[4] Ueber Tubenerkrankung, Zeitschr. f. Geburts. und Gynak., xiii. Band, 2. Heft, p. 301.

[5] American Journ. of Obstet., etc., March, 1887, p. 319.

[6] Archiv f. Gynak., Bd. xxv., Hft. 1, Bd. xxviii., Hft. 3; Am. Journ. Obstet., March, 1887.

[7] Handbuch der Krankheiten der weiblichen Geschlechtsorgane. Leipzig, 1886, p. 449.

[8] Die Entstehung, Diagnose und chirurgische Behandlung der Genitaltuberculose des Weibes. Stuttgart, 1886.

[9] Gaz. Med. de Paris, 1866, No. 41.

[10] Zeitschrift f. Geburts. u. Gynäk., Band xiii., Heft 2, p. 300.

[11] The Medical Record, January 24, February 7, 1885.

[12] Ueber die Aktinomycose des Bauchfells und der Baucheingeweide beim Menschen. Medicin. Jahrbucher der k. k. Gesellsch. der Aerzte in Wien, 1883, p. 477, Fall 4.

[13] Wiener Med. Woch.; Gesellschaft der Aerzte in Wien, 1886, No. 44.

[14] Loc. cit., p. 121.

[15] Lehrb. d. g. Gynäkologie, Wien, 1881, p. 864.

[16] Die Entzundung des Beckenbauchfells beim Weibe, p. 100. Wien, 1883.

PELVIS (Latin, derived from the Greek πελίς, a basin, the same root as our *pail*; Fr., bassin; Ger., Becken; It., bacino). The bony and ligamentous skeleton of that portion of the trunk to which are attached the abdominal limbs. Topographically the term is used to designate the whole region for which the bony pelvis serves as a framework. The appropriateness of the appellation will be evident on placing a human pelvis on a table in a horizontal position, when it will be seen to resemble a somewhat deep wash-basin with the rim broken away in front and behind.

The importance of the structure is great and twofold: First, because it is through it that the weight of the body is supported, and from it that arise the powerful muscles that move the posterior limbs; second, because it forms a bony canal which contains an important portion of the genito-urinary apparatus, and through which the matured fœtus must pass to reach the outer world. The first of these considerations is architectural, the second obstetrical, while both have important surgical bearings.

Of the bones composing the pelvis, two, the sacrum and the coccyx, belong to the spinal column; and two others, the so-called ossa innominata, or hip-bones, belong to the limbs, and constitute the pelvic girdle, which differs remarkably from the thoracic girdle in that it is articulated firmly with the sacrum, thus allowing a firm basis of support.

The sacrum has been said to owe its name to the use made of it by nations who offered human sacrifices, it being held to be particularly sacred to the gods, because it was used as an offering representing the entire victim, it being evident that the victim must be dead if the sacrum was offered. As the bone is frequently found entirely uninjured when other portions of the skeleton have decayed, a rabbinical tradition is said to hold that it is the essential or sacred part of man, which is to be preserved, and from which the entire body is to sprout at the judgment day.* Hyrtl, whose authority on such matters is entitled to considerable weight, holds, however, that these are mere etymological fantasies, and that in the phrase *os sacrum* the adjective is used, as sometimes elsewhere, in the sense of great or important, because it is the largest bone of the spinal column.

The bone presents the appearance of an irregular pyramid, the axis of which has been curved so that the concavity looks downward and forward, the base presenting upward, jointing with the last lumbar vertebra, the apex downward, jointing with the coccyx. Laterally it articulates with the two innominate bones. Its wedge-like form is admirably adapted to the reception of shocks transmitted from below, and constitutes a sort of keystone between the two iliac bones, which, together with it, constitute the pelvic arch. In this situation it not only supports the weight transmitted from the spine, but also resists any strain applied to the pubic bones in front.

Even a superficial examination shows that the sacrum is composed of coalesced vertebræ. These are usually five in number, six or four being occasionally found; but this is usually explained by a corresponding increase or decrease of the vertebral elements of contiguous regions of the spinal column. Accordingly, the main descriptive features of the sacrum depend upon its composite character. There are on the anterior surface transverse lines showing the original division; on the posterior, vestiges of the spinous and articular processes and of the laminæ; on both surfaces, foramina for the exit of nerves from an axial canal, a continuation of the spinal canal of the lumbar region. Anteriorly, obliquely cut grooves lead from the sacral foramina outward, affording to the sacral nerves that lie in them some protection from sliding pressure. Between the grooves arise the digitations of the pyriformis. Posteriorly, from the groove on either side of the spinous processes, great muscular masses take origin, forming part of the great system that sustains the back in an erect position; here they are inextricably blended; higher up they become known as latissimus dorsi (superficial) and erector spinæ (deep). Here also arises the great rump-muscle or glutæus maximus. Proceeding from above downward the characters of the vertebræ become more and more reduced, until at the last two the arch becomes deficient behind, leaving the sacral canal covered only by membrane. Sloughing bed-sores may open it and induce a meningitis. Answering to the sides of the first three vertebræ lateral masses are

* See the following passage from Butler's Hudibras:

"The learned Rabbins of the Jews,
Write there is a bone which they call 'Luz,'
I' the rump of man, of such a virtue
No force in nature can to hurt to;
Therefore, at the last great day
All th' other members shall, they say,
Spring out of this, as from a seed
All sorts of vegetals proceed.
From whence the learned sons of art
'Os sacrum' justly call that part."

added, which represent ribs, and it is here that the bone articulates on either side with the innominate bones.

The coccyx is a similar assemblage of from four to five coalesced vertebræ, but here the vertebral characters have become very much reduced, there being but little more than the original centra, or bodies, with two vestigial articular processes, called the cornua, which unite it with the sacrum. It is triangular in form, and gives attachment to muscles of the perineal floor (coccygeus, sphincter ani) and to the glutæus maximus. Its summit may be easily felt through the floor. It is often anchylosed with the sacrum, especially in those of sedentary occupations, or who ride much on horse-back. This may be a cause of difficult labor, and it is not very unusual to see a red streak on the child's head where it has been forced over an unyielding coccyx. In some cases the anchylosed bone breaks, and the lesion involves the coccygeal nerves which pass out above the cornua, occasioning a severe form of neuralgia called coccyodynia, which can be relieved only by the removal of the bone.

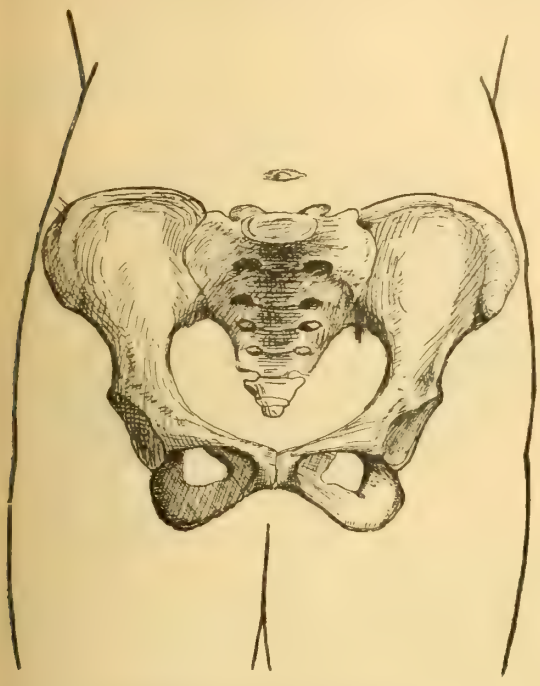

Fig. 2772.—Front View of Female Pelvis.

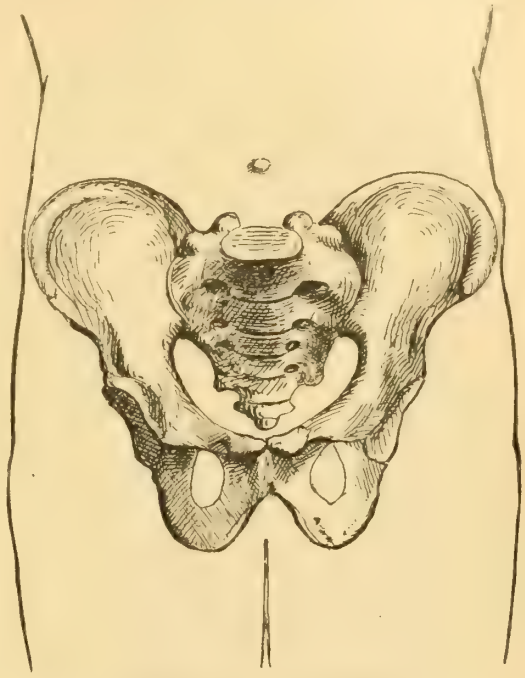

Fig. 2773.—Front View of Male Pelvis.

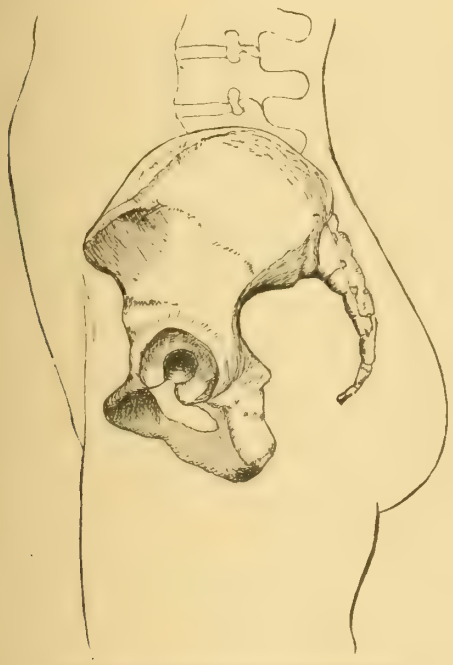

Fig. 2774.—Lateral View of Female Pelvis.

Fig. 2775.—Lateral View of Male Pelvis.

The coccyx corresponds to the caudal vertebræ of lower mammals. In rare instances it has been found to be covered by a special fold of skin, and thus apparent upon the surface as a tail. The subject of tailed men has received more attention than it deserves. The number of the vertebræ in this region are more variable than in any other part of the spinal column. Some sharks have 270, the pangolin 46, the maget (lemur) 3, the gibbon and the frugivorous bats only 2. Broca has pointed out that in considering the question of the number of bones which form the tail, we should not make the division at the sacro-coccygeal joint, as that is a character which may be considered merely a matter of special arrangement for each animal, but should rather commence to count at that part of the sacrum which does not articulate with the innominate bones. Viewed in this manner, the vertebræ which articulate would form a true sacrum, and those which follow would belong to the tail, and be divided into true caudal, having a spinal canal, and false caudal, reduced to centra only. Almost all the lower apes have, according to this view, three sacral vertebræ, as in man. Man would have a tail formed of six to eight pieces, and resemble in this respect the anthropoid apes, they varying merely in the unimportant circumstance of having a few segments more or less.

The innominate bone is also a complex of three originally distinct elements—the ilium, the ischium, and the pubis. When complete, it has something of the shape of two of the twisted blades of a propeller extending on opposite sides of an axial cavity, the acetabulum, which receives the head of the femur. The upper expanded blade is the ilium, the lower, which has a large fenestration called the obturator or thyroid foramen, is formed by the combined ischium and pubis, the pubis forming the anterior portion, the ischium extended backward and downward to form a support while sitting. The upper edge or crest of the ilium is sinuous and thick, and gives attachment in front to the great, sheet-like muscles which form the parietes of the abdomen, and behind to the muscles of the back; its extremities are called the superior iliac spines, anterior and posterior, and, being readily felt, form good landmarks for ascertaining the direction of the deeper structures, and for measuring the relation of the pelvis to other portions of the body. Below the crest is a comparatively thin portion, caused by the hollowing out of the substance of the bone within for attachment of the iliacus muscle, forming the internal iliac fossa; and without, for the attachment of the glutei muscles, forming what is sometimes called the external iliac fossa. The internal iliac fossa supports the weight of the intestines laterally, and forms in the articulated pelvis the lateral portion of what is known as the false pelvis, separated from the true pelvis by a ridge (ileo-pectineal line) passing from the front of the pelvis backward and upward.

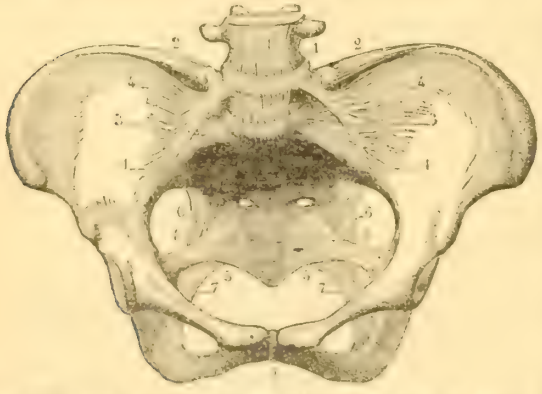

Fig. 2776.—The Articulations of the Pelvis as seen from the Front. 1, Anterior common ligament. 2, its lumbar segment; 3, lumbo-sacral ligament; 4, anterior sacro-iliac ligament; 5, great sciatic ligament; 6, its external border; 7, its internal border; 8, lower sacro-sciatic ligament; 9, symphysis pubis.

The acetabulum or cotyloid cavity appears at the middle of the external surface of the innominate bone. It is hemispherical in shape, composed jointly by the ilium, ischium, and pubis, and receives the head of the femur. It may become perforated by suppuration within the cavity, and thus inflammation of the intra-pelvic structures may be induced. Below, the edge of the cavity is incomplete, giving passage to vessels which supply the joint. The situation of this notch is usually directly downward,

Fig. 2777.—Posterior View of the Ligaments of the Pelvis. 1, 2, 3, 4, 5, Interspinous ligaments; 6, 7, ligamenta subflava; 8, ilio-lumbar ligament; 9, posterior sacro-iliac ligament; 10, its oblique portion, continuous externally with the great sacro-sciatic ligament; 11, posterior superior spine of the ilium; 12, tubercle representing the transverse process of the fourth sacral vertebra; 13, deep layer of the posterior sacro-iliac ligament; 14, insertions of the same; 15, 16, lateral segments of the sacro-coccygeal articulation; 17, posterior ligament of the same; 18, great sacro-sciatic ligament; 19, its sacral insertion; 20, its iliac insertion; 21, its ischiatic insertion; 22, reflected portion; 23, lesser sacro-sciatic insertion; 24, its attachment to the sacrum and coccyx; 25, great sciatic notch converted into a foramen by the sacro-sciatic ligaments; 26, lesser sciatic notch, forming with these ligaments a triangular orifice.

so that it affords one of the best means for establishing the position of the bone.

The united ischium and pubis form the side of the true pelvis. This is constituted by three bony bars which surround the large obturator foramen, closed in during life by a thick sheet of fascia called the obturator membrane. The two anterior bars are known as rami, the upper one being the horizontal ramus of the pubis, the lower being the descending ramus of the pubis above, the ascending ramus of the ischium below. It may be remarked that these terms apply rather to the artificial position of the pelvis, which is given when it is set upon a table, than to its true position in the body during life, as the "horizontal" ramus is far from being horizontal, varying from that by as much as 30° in some subjects. Along these bars are attached the muscles of the perineal floor on the inner side, the muscles of the abdominal wall above, and the adductors and rotators of the femur below. Behind, the ischium expands to a large tuberosity which gives origin to the great hamstring muscles (biceps, semi-tendinosus, semi-membranosus), and serves as an attachment to the great sciatic ligaments. A pointed process (spine of the ischium) divides the posterior border into two notches, the greater and lower sciatic.

Articulations.—The pelvic bones are joined together by five joints, all of which are synchondroses. Two of these are vertebral joints, viz., the lumbo-sacral and sacro-coccygeal; there is one on either side of the sacrum where it unites with the iliac, and one in front where the innominate bones join, called the symphysis pubis.

At the lumbo-sacral joint we have the same general features as in other spinal joints, a union by fibro-cartilage between the body of the last lumbar and the first sacral vertebra, and a pair of arthrodial joints between the articular processes of the two bones. In Fig. 2772 it will be seen that the anterior common ligament of the

spine passes downward upon the sacrum. (See Fig. 2776.) The posterior common ligament within the spinal canal does the same. There are besides these the lumbo-sacral and the ilio-lumbar ligaments, which pass from the ilium to the transverse process of the last lumbar vertebra. The abrupt change of direction of the spinal column at this point forms an angle (sacro-vertebral) which varies very much in individuals, and is known as the promontory of the sacrum. It is one of the landmarks

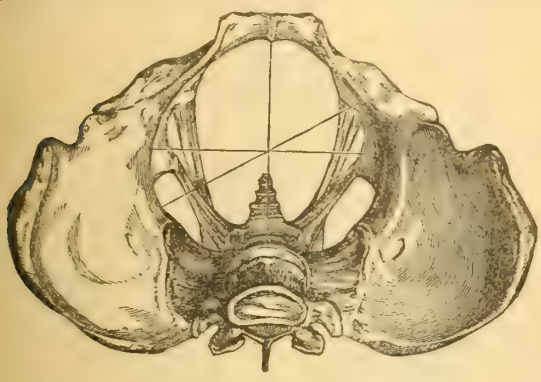

Fig. 2778.—The Superior Strait.

by which a contracted pelvis is known, and cannot, in a properly formed pelvis, be reached by the finger through the vagina. It can, however, easily be felt in a rectal examination.

The joint between the sacrum and the coccyx is very simple, being entirely similar to that between the bodies of the vertebræ. The small amount of movement found in this joint is of a hinge-like character. It is believed to move during defecation, and usually during labor. In the male pelvis the joint is usually obliterated quite early. A number of ligamentous bands have been described, but they appear to have no practical importance beyond that of an investing capsule.

The joint between the sacrum and the iliac bones on either side possesses an incomplete synovial cavity. The ear-shaped articular surfaces may be divided into two parts—an upper, which is clothed with cartilage and a synovial membrane, and a lower, in which the surfaces are connected together by means of an interosseous ligament. The joint is a very strong one, as the entire weight of the trunk is thrown upon the articulation. Injury to it is rather rare, usually a sequel to pregnancy, but when it occurs is of a serious nature. The joint is strengthened by peripheral ligaments called anterior and posterior (see Fig. 2773).

The articulation between the two pubic bones in front is the most interesting joint in the pelvis. It is united by means of fibro-cartilage, which occasionally contains some traces of a synovial cavity. During pregnancy it swells and relaxes, and there is thus obtained a mobility of the joint which may persist for some time after delivery. Four peripheral ligaments are described: anterior, posterior, superior, and inferior. Malgaigne considered that the height of the symphysis increased considerably after the menopause, being 38 mm. at forty-five years, and 45 mm. at seventy and eighty years.

It being obvious that the parting of the bones at this joint increases the outlet of the pelvis, it has been proposed to divide the ligaments here, instead of performing Cæsarean section when natural labor is impossible. This operation was actually performed several times during the last century by M. Sigault, but was found unsatisfactory, as the patient was lamed for life and the advantage gained was very trifling; in order to gain half an inch in the antero-posterior diameter the bones must be separated at least two inches and the sacro-iliac ligaments lacerated. It occasionally happens that from frequent child-bearing the joint becomes quite loose, and walking and standing are difficult.

The arrangement of the abdominal muscles in the insertion about the joint is such as to draw the ends of the bones together, so that during the bearing-down pains of labor the joint is strengthened. In many of the lower animals the pubic bones separate to a very considerable extent during labor, but it would doubtless be impossible to accommodate this to the erect position. In the marsupials two small bones articulate directly above the symphysis pubis, and extend upward into the wall of the pouch which holds the young. The only relic of this in man is in the two small muscles which arise directly above the symphysis, called the pyramidales. These are the muscles which in marsupials contract the pouch. They appear to be of no other use in man than to serve as tensors of the fascia covering the abdominal muscles.

Besides the bands connected with the joints, there are two other strong ligaments which bind together the sacrum and the innominate bones. These are the greater and lesser sacro-sciatic ligaments (Fig. 2777). The great sacro-sciatic ligament appears to be a continuation of the sacro-iliac, passing to the lateral parts of the sacrum and the coccyx, and from thence to the external surface of the ischium. It is somewhat narrower in the middle than at either extremity, and presents two rather sharp edges. Its interlaced fibres are somewhat extensible, so that it does not offer any obstacle to the movement of the coccyx during labor. The lesser sacro-sciatic ligament passes from the side of the sacrum and coccyx to the spine of the ischium. It lies anteriorly to the great ligament. By means of these two bands the sciatic notches are converted into foramina through which pass important structures; through the greater or superior foramen the pyriformis muscle, with the gluteal vessels and nerve above it, the sciatic vessels and nerve below it; through the lesser, the obturator internus muscle with its nerve. The pudic vessels and nerve have a peculiar course, passing around the spine of the ischium from within outward, and then inward again, running along the border of the great sciatic ligament, protected by a sharp, thin process called the falciform ligament. These ligaments give origin to the gluteus maximus muscle, and the tendons of the biceps, the semi-tendinosus and the semi-membranosus pass directly into them, so that the pull of these muscles is exerted along the sides of the sacrum and the posterior part of the ilium, as well as along the tuberosity of the ischium (Morris).

Taken as a whole, the pelvis represents an osseous ring of considerable strength. The weakest parts are at the symphysis and the sacro-iliac joints. The bone is usually broken only by some powerful mechanical force, such as the kick of a horse or crushing between railway cars.

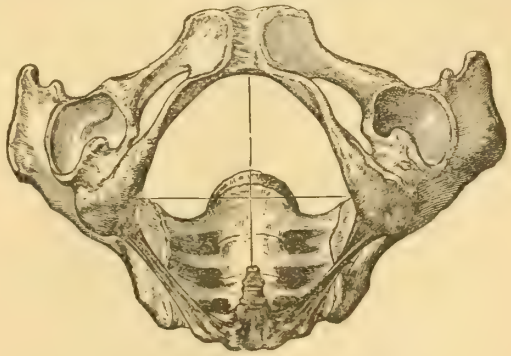

Fig. 2779.—The Inferior Strait.

Fracture takes place in front through the rami more frequently than elsewhere. There are cases on record of heavily loaded wagons passing over the pelvis without breaking it.

The circular crest that separates the true from the false pelvis forms the edge of the inlet or superior strait (see Fig. 2778). It is here that the fœtus first engages during parturition. It is of a heart-shaped form. The lower opening of the pelvic canal, called the inferior strait (see Fig. 2779), is also heart-shaped and somewhat

smaller than the upper one. It is bounded by the rami in front, on the sides by the tuberosities of the ischium, the sciatic ligaments, and the coccyx. That part of the pelvic canal between the inferior and superior straits is called the cavity of the pelvis. It is customary to divide this into four regions, an anterior, a posterior, and two lateral. The anterior comprises the symphysis pubis, the posterior surface of the body of the pubis, and the obturator foramen with its membrane. It is limited by a line passing from the tuberosity of the ischium to the ilio-pectineal eminence. The posterior region is formed by the anterior surface of the sacrum and coccyx. The lateral regions are, of course, comprised between the anterior regions and the posterior. Each is again subdivided into two portions called the anterior and posterior inclined planes. The anterior comprises the internal face of the ischium and that part which corresponds to the acetabulum. Its direction is oblique, downward and backward. The posterior inclined plane is entirely composed of soft parts, and is directed downward and forward. The planes meet at a line passing through the spines of the ischia.

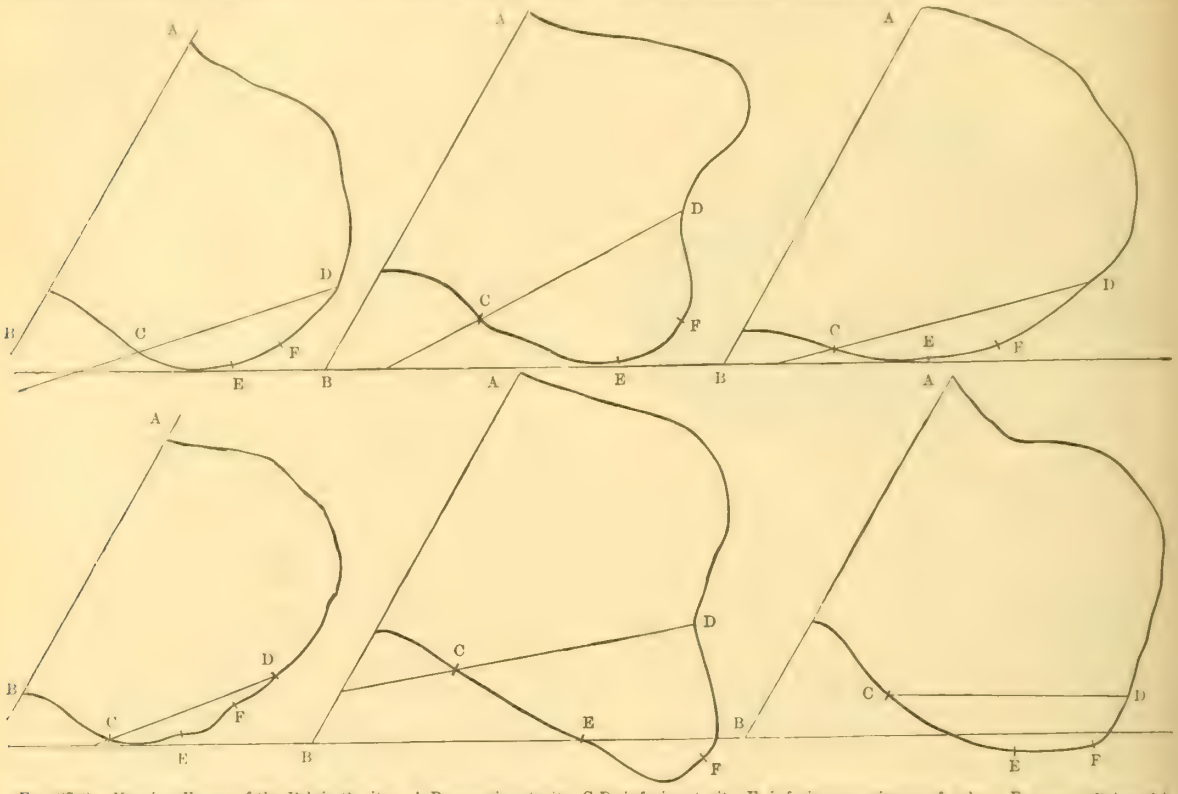

Fig. 2780.—Varying Forms of the Pelvic Cavity. A B, superior strait; C D, inferior strait; E, inferior commissure of vulva; F, anus. (Boissard.)

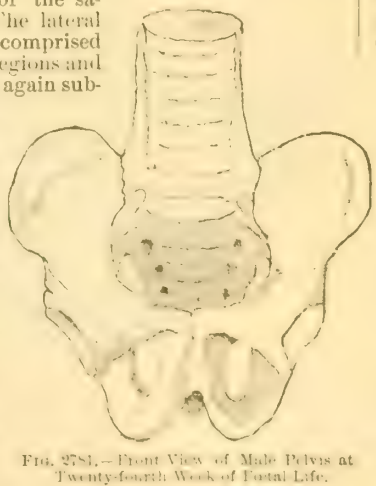

Fig. 2781.—Front View of Male Pelvis at Twenty-fourth Week of Fœtal Life.

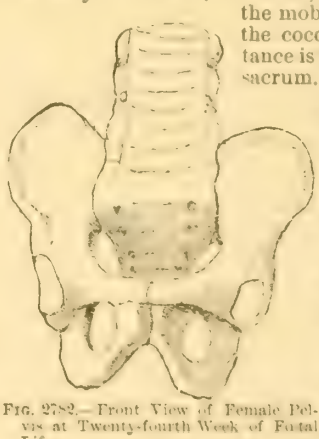

Fig. 2782.—Front View of Female Pelvis at Twenty-fourth Week of Fœtal Life.

For obstetrical purposes certain measurements of the pelvis are made, called diameters. In the false pelvis the distance between the iliac crests and the two superior iliac spines is taken. In the superior strait there are made an antero-posterior measurement in the middle line, called a conjugate diameter; the measurement from side to side, between the most widely separated portions of the ilio-pectineal line, called the transverse diameter; and oblique diameters, taken between the sacro-iliac joint and the ilio-pectineal eminence. In the cavity of the pelvis the antero-posterior measurement is usually taken from the middle of the symphysis pubis to the point of union of the second and third sacral vertebræ. Meyer proposed a normal conjugate taken from the upper border of the symphysis to the most retreating portion of the third sacral vertebra. At the outlet the conjugate diameter is taken from the lower border of the symphysis to the tip of the coccyx. This is, of course, variable, according to the mobility of that bone. If the coccyx is absent, the distance is taken to the end of the sacrum. The transverse diameter is measured between the tuberosities of the ischia. The axis of the pelvis is a line halving all the conjugate diameters that can be drawn.

For practical purposes it is only necessary to speak of these measures approximately, and they are usually given as follows for the female: Superior strait, conjugate diameter, 4¼ inches; superior strait, transverse diameter, 5¼ inches; superior strait, oblique diameter, 5 inches; inferior strait, conjugate diameter, 3¾ to 4½ inches; inferior strait, transverse diameter, 4¼ inches. Besides these, we have the widest distance between iliac

crests, 10 inches; widest distance between antero-superior iliac spines, 9 inches.

For anthropological purposes Garson recommends the following list of measurements: Sacral length, vertical length of the five sacral vertebræ; sacral breadth, maximum breadth of first sacral vertebra; width between antero-superior spines of the ilia; width between crests of the ilia; maximum length of the innominate bone or pelvic height; maximum breadth of the ilium; width between the postero-superior spines of the ilia; width between the posterior margin of the acetabulum and the symphysis pubis; the pubo-ischial depth; the antero-posterior diameter of the brim; the transverse diameter of the brim; antero-posterior diameter of the outlet; transverse diameter of the outlet; subpubic angle.

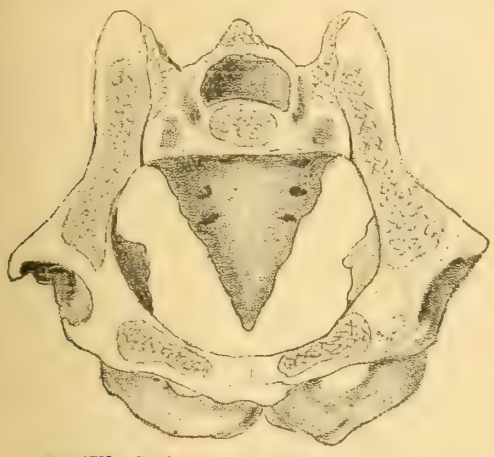

Fig. 2783.—Section through Pelvis of a Boy at Birth.

Fig. 2784.—Section through Pelvis of a Girl at Birth.

Boissard has called attention to the fact that the pelvic excavation, instead of having the regular form usually described by obstetricians, is rather purse-like in shape, composed of two lateral walls nearly parallel and rectilinear, and one inferior or perpendicular to the others. He thinks that the Tarnier forceps shows that this is the case, as the fœtal head descends after being seized at the superior strait without affecting the needle, until it touches the perineal floor. Having reached the floor, it tends to depress the cavity formed by the soft parts. This increases the height of the subpubic space. The pole makes exit here, following a line almost oblique to that it had followed previously.

Fig. 2780 shows a number of outlines of antero-posterior sections of the pelvis, which were actually measured on the cadaver by him.

The distorted appearance of these figures is probably owing to the fact that the inclination of the superior strait to the horizontal plane is invariably taken at sixty degrees. This is from the observations of Naegeli, as based upon an examination of only eleven pelves. It is altogether probable that this inclination is subject to wide variations. As far as the author is aware, there is no perfectly satisfactory rule for determining the relation of the pelvis to the horizontal plane.

Meyer, who is now followed in Germany, measures, in the living subject, the distance from the ground to the pubis, the distance from the ground to the fifth lumbar spine, and, finally, the distance from that spine to the symphysis. He seems to have studied only sixteen subjects, who gave an average of fifty-one degrees, varying between forty and seventy degrees. In cases of coxalgia the sacro-vertebral angle is very much distorted.

Charpy thinks that the inclination of the superior strait does not properly express the inclination of the pelvis;

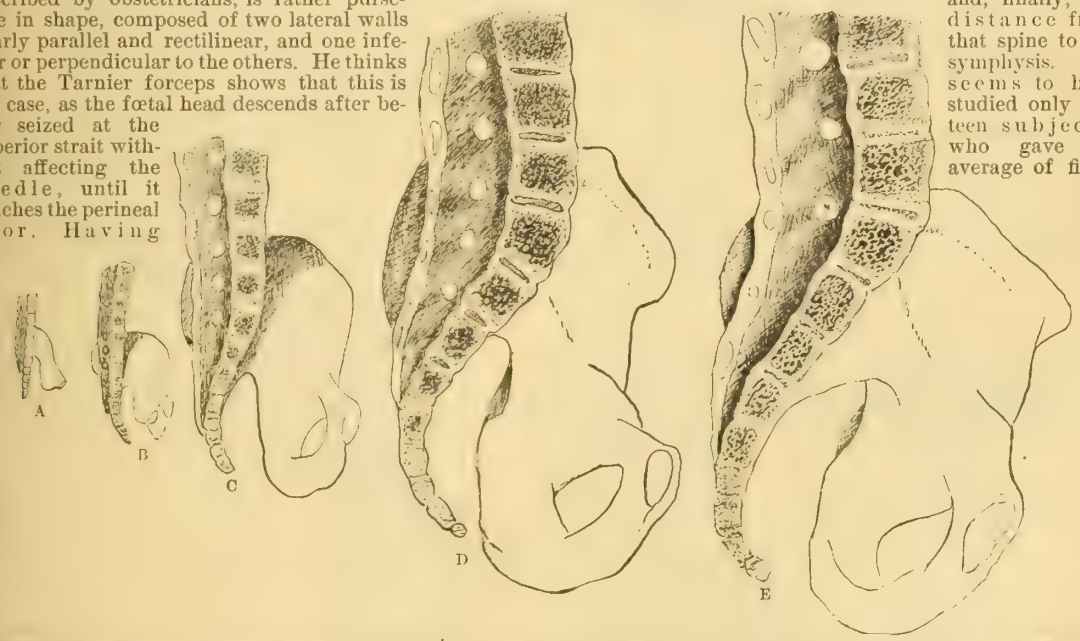

Fig. 2785.—Sagittal Sections of Fœtal Pelves. A, boy, middle of third month; B, girl, second half of fourth month; C, girl, second half of sixth month (twenty-third and twenty-fourth week); D, boy, tenth month (thirty-seventh to thirty-ninth week); E, girl, birth (forty weeks).

he recommends instead that we should measure the inclination of the symphysis pubis to the vertical line.

The axis of the superior strait is a line perpendicular to the plane of that strait at its central point. It very nearly coincides with a line drawn from the tip of the coccyx to the umbilicus. That of the interior strait is similarly obtained, and when produced reaches the promontory of the sacrum.

Fig. 2786.—Sacrum of a Child of Eleven Months. 1, 1, Ossific points for bodies; 2, 2, lateral points; 3, 3, intervertebral ligaments.

Considerable sexual differences are found in the pelvis. These generally arise from the larger capacity of that of the female. In the female pelvis the sacrum is wider and straighter, and the promontory less projecting. The cavity is shallower, and the horizontal diameters broader. All the lateral portions, like the iliac spine, the acetabulum, and the tuberosities are wider apart (see Figs. 2772, 2773, 2774, and 2775), and the pubic arch has a wider span, and the height of the pubis is less. It is usually stated that these sexual characters do not begin to appear before puberty, but Fehling has shown that they begin as early as the fourth month of fœtal life, and are marked by the second half of the fifth. The first that shows is the excess of breadth of the symphysis pubis over its height. This will be noted in Figs. 2781, 2782, 2783, and 2784.

Hennig's description of the development of the pelvis is much as follows: Between the primitive vertebræ and around the chorda which they inclose is built the membranous vertebral column, with a membranous arch inclosing the spinal cord. The intervertebral ligaments remain membranous. The chorda, on the contrary, commences in the second month of fœtal life to divide into cartilaginous vertebræ. These send upward cartilaginous arches which first close at the fourth month. The lateral portions of the cartilage forming the sacrum unite, as a rule, while those of the last vertebræ, forming the coccyx, make either no arch at all or a very incomplete one, so that the coccygeal vertebræ remain, after the union of the sacrum with the coccyx, movable for a considerable time on each other. The ossification of the spinal column begins at the end of the second month, and reaches the sacrum at the fifth. In the seventh week there first arises in either half arch a point of ossification. Shortly thereafter, in each vertebral body, a single centre is formed out of two originally separate portions. In the fifth month of fœtal life the ossifying points reach the surface of the cartilage in the lumbar vertebræ. The usual five vertebræ of the sacrum are each formed of three parts, but in the first three or four vertebræ there also arise, from the sixth to the eighth month, accessory, rib-like portions, which are attached to the lateral anterior parts. Rosenberg has observed in the last vertebra, and also in the coccygeal vertebræ, that the first laying down of the cartilage is bilateral. This, doubtless, explains the two separate points of ossification which have been described at the posterior end of the lowest coccygeal vertebra of a girl of ten years. Fehling remarks that the ossific point of the first sacral vertebra is higher in front, that of the fourth higher behind. At birth this difference in height equals one millimetre (see Fig. 2785).

Fig. 2787.—Ossification of First Sacral Vertebra. 1, 1, Body; 2, 2, lateral points; 4, 4, centres for arch.

Fig. 2788.—Epiphyseal Ossification of Last Sacral Vertebra. 1, 1, Body; 2, 3, epiphyses.

Fig. 2789.—Development of the Coccyx. 1, 1, Centres for bodies; 2, 2, articular processes; 3, 5, epiphyses.

The lateral portions of the sacrum are first laid down in the third month, and first curved forward notably in the sixth month. The longitudinal curve of the sacrum begins in the middle of the third month. As the lumbar vertebræ commence to ossify in the fourth month of fœtal life, the arches are at birth almost completely ossified, and become quite so at seven weeks after birth, closing in behind at the end of the first year, and uniting with the bodies of the lower lumbar vertebræ at the end of the third year. Then the spinous processes of these vertebræ are also ossified.

Besides the three principal points which form the masses of the vertebræ there are others added in later years. The first, for the mammillary processes of the lumbar vertebræ; second, for the tips of all the spinous processes (about puberty); third, tips of the transverse processes (these two last may be single or double); fourth, connected with the articular processes; fifth, at the ends of the bodies of the vertebræ as epiphyseal plates. All these nuclei first appear between eight and fifteen years, and begin to unite about the fifteenth year with the main body. At the end of the fourth fœtal month the sacral vertebræ of the fœtus decrease in breadth from above downward (standing position). The ossified spinous process of the first sacral vertebra unites in the third year after birth; of the second vertebra, in the fifth year; of the third, sixth year; of the fourth, in the eighth year. The union of the middle piece with the wings occurs in the lower sacral vertebræ in the third year; in the upper between the fifth and fourteenth years. The sacral vertebræ also receive, after puberty, bony epiphyseal plates.

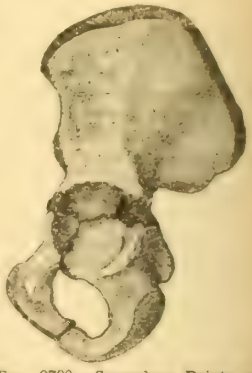

Fig. 2790.—Secondary Points of Ossification of the Ilium.

The coccyx obtains its first bony nucleus in the upper vertebra before birth; in the second vertebra, from the first to the fifth year; in the third, during the sixth year; and in the fourth, from the tenth to the fourteenth. There are cases of five coccygeal vertebræ. Rosenberg noted that when the sacrum ends with the twenty-ninth vertebra there were six coccygeal vertebræ. The union of the coccygeal vertebræ occurs in some persons at fifteen years.

Fig. 2791.—Ossification of the Ilium by Three Primitive Points.

In the ossification of the remaining portions of the pelvis, there are evident traces of the original rod-like character of the bones which compose it (see Fig. 2792), each separate bone having a

primitive centre which may be considered as corresponding to the diaphysis of a long bone, and secondary centres at the extremities, corresponding to the epiphyses. There are, besides, certain other centres which might be called tertiary or accessory, relating to modifications introduced by the pull of muscles.

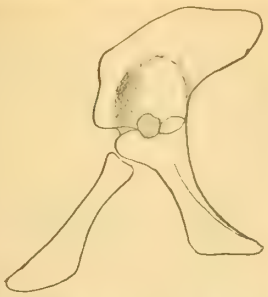

Fig. 2792.—Innominate Bone of Alligator, showing the Rod-like Character of the Separate Elements.

The primitive centres are shown in Fig. 2791. That for the ilium appears in the third or fourth month, for the ischium in the fourth or fifth month, for the pubis from the fifth to the seventh month. The three bones radiate from the acetabular cavity, being separated at the

Fig. 2793.—Pelvis of the Horse.

bottom of the cup by a triradiate or Y-shaped piece of temporary cartilage. At birth nearly the whole of the

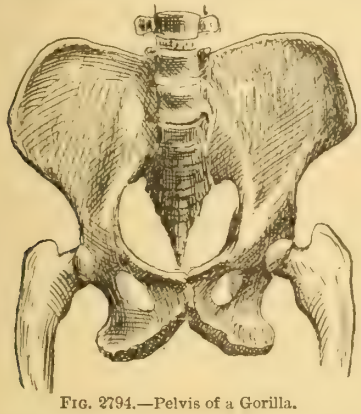

Fig. 2794.—Pelvis of a Gorilla.

acetabulum is cartilaginous, as are also the peripheral extremities of the three segments, viz.: the crest of the ilium, the tuberosity and ramus of the ischium, the body and inferior ramus of the pubis.

From the sixth to the fourteenth year ossific nuclei begin to appear in the Y-cartilage (epiphyses juncturæ).

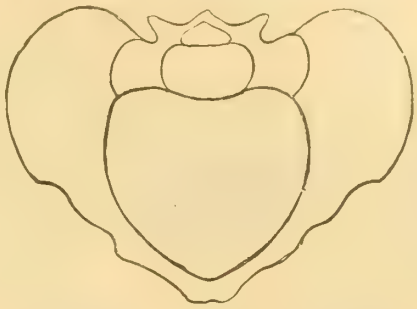

Fig. 2796.—Pelvis of an Andaman Islander. (Garson).

One of these, belonging to the pubic bone, may remain separate for some time, and even persist in adult life as a cotyloid bone (os acetabuli), crowding the pubis out from participation in the acetabular cavity. The completion of that cavity usually takes place by the eighteenth year, by the junction of the epiphyses with the main bones.

Fig. 2797.—Pelvis of a Young Maori. (Hennig.)

The marginal epiphyses are formed at the crest of the ilium, the tuberosity of the ischium, and the symphysis

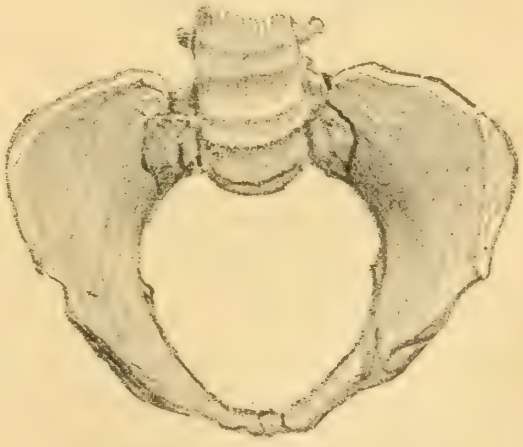

Fig. 2798.—Pelvis of a Negress. (Hennig.)

pubis. These are shown in Fig. 2791. They unite from the twenty-third to the twenty-fifth year.

Accessory centres are found for the anterior superior

Fig. 2795.—Diagram of European Pelvis, seen from above. (Garson).

iliac spine, the spine of the ischium and of the pubis, and for the ileo-pectineal eminence.

Upon comparing the human pelvis with that of lower animals we come to see that its peculiarities are such as are entailed by the upright position. The original characteristic of the innominate bone, as three separate, rod-

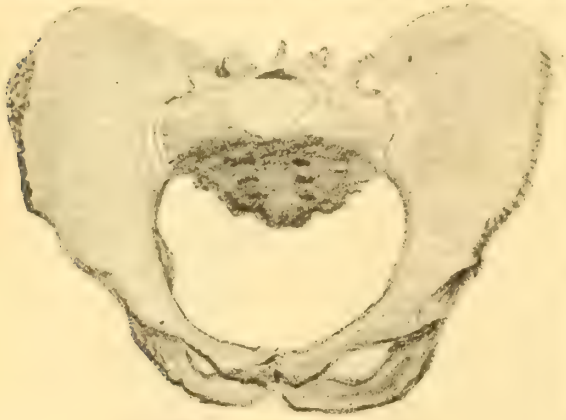

Fig. 2799.—Pelvis of an Aino. (Hennig.)

like bones united at the acetabulum, is shown in a striking manner in the alligator's pelvis (Fig. 2792).

This is also indicated by the ossification of the pelvis; for the accessory points at the crest of the ilium, at the symphysis pubis, at the tuberosity of the ischium, and in the acetabular cavity may be considered as terminal epiphyses, similar to those which are usually found upon long bones. Even in the higher mammalia the rod-like character of the bone remains to a considerable extent, as will be seen by Fig. 2793.

In animals that have to support the weight of an extremely heavy body (elephant, mastodon), the pelvis

Fig. 2800.—Pelvis of an Individual belonging to the Stone Age. (Hennig.)

flares out laterally into a strengthening arch. When the upright position begins to be assumed, the lateral expansions become necessary for the support of the viscera. The antero-posterior diameter remains longer.

In very low human races certain characters are found which appear to be reversive—that is to say, like the nearest higher mammalia. Figs. 2795 and 2796 show a diagram of the pelvis of an Andaman islander, as compared with that of a European. Figs. 2797, 2798, 2799, and 2800 are also examples. *Frank Baker.*

PEMPHIGUS. Pemphigus is a disease of the skin characterized by the appearance of watery blebs, varying in size and number, coming out in successive crops, and usually running a chronic course.

A form of acute pemphigus is described by some writers, in which one or more crops of bullæ appear and run a rapid course, usually accompanied by more or less fever. The variety does not appear to have been accurately distinguished from other forms of skin disease. Pemphigus is usually divided into two varieties—pemphigus vulgaris and pemphigus foliaceus.

Pemphigus vulgaris commonly begins with symptoms of fever, chills, and frequent pulse, malaise, vomiting, etc. The fever is apt to continue with the eruption, taking on a remittent type, falling off with the diminution of the eruption, and starting up again with a fresh outbreak.

The first symptom is usually the appearance of flat, papular lesions, or quaddels, like the eruption of erythema multiforme; and from these lesions, or occasionally directly from the sound skin, spring the tense, firm bullæ, varying in size from that of a pea to that of a hen's egg, and filled at first with clear serum, which afterward becomes cloudy.

The number of lesions present at any one time varies from one or two to fifty or a hundred; their distribution is usually irregular. When the lesions show themselves in groups, or according to a circinate arrangement, and especially when, in connection with this, they are anomalous in character or course, or are accompanied by severe itching, there may be reason to suspect the disease to be other than typical pemphigus.

The individual lesions, once fully developed, retain their original size or grow by the addition of fresh lesions to their periphery, or occasionally increase in diameter and run a typical course. Their contents, at first as clear as water or wine, yellow, or occasionally tinged with blood, soon become cloudy, and, after a day or two, turbid and purulent; the cover of the bleb dries up as such, or forms, after bursting, a crust with the exudative material and blood. After this crust has separated the newly covered skin is at first bluish-red, and then becomes pigmented, the brown color lasting some weeks.

The process goes on in the manner mentioned, the increase in fever and the eruption of erythema and blebs alternating with remissions. When the blebs and crusts are thickly crowded together, and have become separated by the more recent exudate, the skin over large areas becomes hot, œdematous, painful, and marked by lymphangitis, sometimes complicated by adenitis. Among the subjective symptoms may be mentioned moderate burning and itching in and about the lesions, pain and tension in places where the crusts are thick or the corium exposed, sleeplessness, want of appetite, and thirst during the stage of exacerbation. The patient becomes much exhausted by the persistence of the fever and other symptoms.

At the end of from two to six months the process is ended, the blebs cease to form, the fever abates, and the patient recovers his strength and appetite. There may never be a return of the affection; but more commonly the disease attacks the patient again after the lapse of some months or a year, and ends with the second attack. Occasionally the attacks succeed each other with decreasing intermissions until the process becomes a continuous one. Still milder forms of the disease are at times met with, in which there is no fever, and only a few lesions come out with each remission; or one or two blebs may come out daily for years; or, very rarely, there are cases in which the eruption shows itself only in some circumscribed area, a few blebs appearing upon the bluish, cool skin of the nose, fingers, or toes.

On the other hand, malignant forms of pemphigus are occasionally met with. Great numbers of blebs, frequent recurrence or continual eruption of new lesions, permanent and continued fever, and rapid failure of strength are here met with. The severe form of the disease is sometimes characterized by a change from pemphigus vulgaris to pemphigus foliaceus, in which, instead of raised blebs, the corium appears red and raw, or covered with gangrenous or croupous exudation. Occasionally vegetations show themselves on the raw patches. These forms of pemphigus may terminate favorably, but they are apt to be serious or fatal.

Pemphigus pruriginosus must be classed among the more severe forms of the disease. The severe itching which characterizes this form not only pulls down the patient by interfering with sleep, but gives rise to char

acteristic external symptoms resulting from the rubbing and tearing of the early urticaria-like lesions before bullæ have had time to form. Few bullæ are therefore to be seen, but excoriations, crusts, and eczematous patches, with stripes and spots of pigment scattered irregularly over the skin, give a picture unlike the other forms of the disease (Kaposi). Some American writers include this form, justly I think, among the varieties of Dermatitis herpetiformis.

Pemphigus foliaceus is characterized by the formation of flaccid bullæ, the scanty contents of which hang in the most dependent parts. The lesions spread on their periphery, where the skin is constantly becoming loose and separating. Large areas of denuded corium are gradually formed, which become coated with a thin, varnish-like covering of attenuated epidermis. This cracks in all directions, and the condition of the patient, whose least movement causes some fissure of the skin, becomes pitiable in the extreme. This form of pemphigus is almost always fatal sooner or later.

Either variety of pemphigus may attack the mucous membrane of the mouth, vagina, etc. When single blebs occur on the buccal mucous membrane only a transitory inconvenience is caused, although when the epiglottis is involved there is some danger of suffocation. When numerous lesions occur in the mouth, about the fauces, etc., the patient's condition becomes most pitiable; neither food nor drink can be swallowed, and death is apt to result. When the croupous form of pemphigus occurs on the eyelids and conjunctiva, blindness may result. Fortunately these forms of the disease are most rare, as is also pemphigus of the air-passages.

The bleb of pemphigus is a very superficial lesion, much more so than the vesicle of herpes, eczema, etc.; it rarely leaves a scar.

The extreme rarity of the disease (only 89 cases in 58,617, or 0.151 per cent., in the statistics of the American Dermatological Association), and the diversity in the course of the disease and the symptoms shown, have prevented, thus far, any reasonable etiological hypothesis from being brought forward. It seems probable, however, that disease of the nervous system may play an important part in its causation.

Pemphigus is not contagious. The cases reported as such, especially among children, have probably been impetigo contagiosa or eruptions of syphilitic origin. The employment of the term pemphigus syphiliticus to designate the bullar syphiloderm has helped to cause confusion, and should be discontinued.

A form of epidemic pemphigus has been described by Ritter and others, as occurring among children, particularly in charitable institutions. Though called exfoliative dermatitis, the affection has marked affinities with pemphigus foliaceus. It is very fatal.

The diagnosis of pemphigus is usually not difficult. The presence of blebs does not necessarily indicate pemphigus, as these are developed in other diseases and by artificial means (see *Dermatitis medicamentosa*). So-called "pemphigoid" eruptions, obscure in origin and nature, are sometimes met with, but their course is not that of pemphigus properly so called (see *Dermatitis herpetiformis*). Pemphigus is not, under any circumstances, to be confounded with the bullous syphiloderm. The latter is a purulent bleb, drying up into a thick crust with an ulcer underneath. Erythema multiforme, in the bullous form, and impetigo contagiosa are occasionally mistaken for pemphigus. A reference to these diseases under their respective titles will show their characteristic points.

The internal treatment of pemphigus is important. The general history and circumstances of the case must be looked into, and any defects of constitution or circumstances remedied. Among drugs, arsenic is most potent. Fowler's solution, in doses of four minims, thrice daily at first, increased gradually to the limits of tolerance, may be given. Wine of iron is the best excipient for Fowler's solution in these cases. Arsenic produces its effects slowly, and it should be persisted in for months, if necessary, without expecting a cure or even amelioration in so chronic a disease. Quinine is of value, and in some cases linseed-meal, in ounce doses, with milk, has proved valuable. Cod-liver oil and stimulants may be required at times. The patient should be allowed to rest, and should be free from worry and anxiety, so far as this is practicable.

The local treatment of pemphigus is also of importance. The blebs should be punctured and evacuated so soon as they have formed. Soothing and astringent lotions, and especially dusting-powders, such as that composed of equal parts of oxide of zinc and starch, may be employed. Baths containing bran, starch, or gelatine may be recommended in some cases. The continuous bath, in which the patient lives, eats, and sleeps for months, has been employed in severe cases. Occasionally water does not agree, and in these cases mild ointments, as that of oxide of zinc or diachylon, may be prescribed.

Pemphigus, as has been intimated, runs an extremely uncertain course. Relapses frequently occur. When the blebs are numerous, flaccid, imperfectly formed, and inclined to rupture, and when they are rapidly and frequently formed, the prognosis is unfavorable. Repeated febrile attacks also indicate an unfavorable tendency. On the whole, then, we may say that the prognosis of pemphigus must be very guarded, as, even when beginning as a slight attack, an unfavorable turn may be taken and the case may end fatally. *Arthur Van Harlingen.*

PENIS, CONGENITAL MALFORMATIONS OF THE.

The penis is subject to very great variations in size and shape. To describe all the forms that it may assume is hardly possible. Only those deformities which are sufficient to impair its functions or render the organ an object of special attention will be noticed.

Absence of the Penis.—An interesting case has been reported by Goschler[1] and quoted by Guyon.[2] Goschler was consulted for orchitis by a man of unusual strength, large, and well built, save his genitals. The scrotum was perfectly formed, but the penis was completely wanting, not the slightest sign of one existing at the normal situation. The right testicle and cord were normal, but the left testicle was the seat of an acute orchitis. Upon the anterior wall of the rectum, at the height of four lines, was situated, upon the median line, a rounded opening which gave exit to the urine. In front of the anus, on the median line, was an enlargement which was compared to a cock's-comb, and which swelled whenever there was genital excitement, to which the patient was very subject. The erection lasted some minutes, and was followed ordinarily by the discharge of sperm from the opening in the rectum.

Double Penis.—The penis is occasionally double, though the recorded cases are exceedingly few. Van Buren and Keyes describe a case in which two well-developed organs were attached side by side at the normal position at the pubic symphysis. They were both included in a common integument up to the glans. Each glans was separate and distinct, but the left was impervious. In 1844 M. Velpeau presented, for M. Gorre, of Boulogne, to the Académie des Sciences, a child, aged eight months and a half. It had three legs; in front of the normal pelvis were two penises, separated at their origin by a distance of about four centimetres. The correspondingly double scrotum contained a single testicle on each side. Each penis had a urethra. The two canals appeared to communicate with a single bladder; at least, when the emission of urine took place, it issued at the same time and in the same quantity from each urethra.

The prepuce presents very great variety. It is sometimes developed on the under surface and wanting on the dorsum; it may be unnaturally long or it may be entirely absent, and in this latter condition operations have been undertaken for its restoration. The abnormalities that have any practical worth are abnormal length and narrowness of the foreskin, causing phimosis, and abnormal shortness of the frænum. Phimosis is treated of under a separate heading.

Abnormal Shortness of the Frænum.—The frænum shows the greatest possible variations in length and

thickness. It may be entirely wanting, and is rarely present in cases of hypospadias. It may be very thin and delicate in structure, so that it is easily torn in the first coitus. The only form which really deserves consideration as a malformation is an unusual shortness and thickness; a shortness so great that when the prepuce is retracted the frænum draws upon the glans in such a manner as to cause the meatus to point downward. An angle is thus produced in the urethra sufficiently acute to interfere with micturition. The tension on the frænum in these cases is greatly exaggerated when the organ is erect. This tension may be sufficient to render erection painful and interfere with the genital functions. Occasionally this deformity is sufficient to entirely prevent emission during connection, the spermatic fluid dribbling away after the erection has subsided. These cases are easily treated by a slight incision through the frænum. Such a cut, of course, entirely frees the glans from traction, but it must be borne in mind that a small artery runs through the frænum which is occasionally a little obstinate about retraction, and may need to be tied.

Narrowness of the Meatus.—The meatus is ordinarily and normally the narrowest part of the urethral canal, an anatomical peculiarity which permits the stream of urine to be projected further than if the canal were uniform. The degree of narrowing varies very greatly within what may be regarded as normal limits. Extreme narrowing is sometimes seen, and may produce any of the various symptoms that follow stricture of the canal itself. Guyon quotes a case of Demarquay[3] as follows:

A young man, thirty-six years of age, had an incomplete congenital atresia of the meatus so marked that an ordinary probe could not be introduced. Micturition was excessively slow, and performed only at the expense of decided muscular efforts. Excess of any sort rendered the difficulty greater. Pressure with the fingers was insufficient to entirely empty the canal, so that there always remained after micturition a certain quantity of urine which issued drop by drop and soiled his clothes. Without known exciting cause other than the congenital deformity of the meatus, an abscess formed at the perineo-scrotal angle, which was followed by a fistula. To cure the fistula it was, of course, necessary to give free exit to the urine at the meatus. At the operation Demarquay found the atresia so nearly complete that it was impossible to introduce even the finest probe. Maintaining the meatus at a proper size caused the fistula rapidly to contract and heal.

Complete Imperforation.—The urethra may be occluded at any point—at the meatus by integument alone, by mucous membrane, by transformation of any segment of the urethra into a solid cord, and perhaps by simple agglutination of the urethral walls. Attention is early attracted by the efforts made by the infant, and by its expressions of pain. Meconium is passed, but otherwise the napkins are not wet. During the straining of the infant the penis swells, assumes a half-erect condition, and the distended urethra makes a very appreciable enlargement on the under surface. It is possible, during the momentary dilatation of the urethra behind the obstruction, which accompanies the straining of the infant, to determine the point at which the obstruction is seated. Guyon lays especial stress upon the value of the knowledge gained by examination during the child's efforts, in attempts to remedy the defect by surgical means. In the *Lancet* of 1874 Dr. Grubb, of Waterbeach, described a case of imperforate urethra. When twelve hours old the infant had not passed water. The glans was swollen into a round knob and the prepuce retracted, but no meatus nor any depression to mark its site could be found. An incision was made, and an attempt made to pass a probe, but without immediate result. A few hours later, however, the bed was saturated with urine, which was afterward seen to issue from the site of the incision. Before the incision the infant was vomiting, had a weak pulse, and was apparently dying. In reply to Dr. Grubb's communication, Dr. Arthur W. Edis reported a case from the British Lying-in Hospital. After twenty-four hours the child was restless and apparently in pain, and had passed no water. The prepuce was imperforate and adherent to the glans. A small crucial incision was made, and, after a prolonged trial, a probe was made to traverse the direction of the urethra. The impression conveyed was that the walls of the urethra were firmly adherent for about an inch. After the probe had travelled that distance a jet of urine followed.

Guyon cites a case of Dr. Gourdon in which both orifices were impervious. The meatus was obliterated by a slightly resisting membrane, which was recognized and punctured soon after birth. Fourteen hours after birth the infant had passed no water and a catheter was introduced. It penetrated to the neck of the bladder, when it was arrested. After withdrawal and a repeated attempt, made with care, Dr. G. was persuaded that an abnormal obstacle opposed the advance of the catheter, and applied some force to the catheter. After a sensible resistance the instrument passed abruptly into the bladder. On its withdrawal the urine followed with great force.

In many of the cases in which the urethra is occluded there exists a still further anomaly, but one which may be regarded as compensatory, in the existence of an abnormal orifice. Such an orifice may be situated in the urethra, behind the impervious portion, or in connection with the bladder. Some of the cases of hypospadias are included under the first head. In other cases the urethra opens into the rectum, as in the case already described in which the penis was entirely wanting. A continued patency of the urachus sometimes occurs in connection with imperforate urethra. When no escape for the urine is provided, the effect upon the urinary secreting and retaining apparatus, even before birth, may be very serious. Simpson reported a case in which the urethra was imperforate near the prostate, and the bladder was ruptured. Behind, at the summit, was a perforation about which the vesical walls were atrophied, as if in consequence of excessive dilatation. In a case of Fearn's the ureter, when inflated, was nearly an inch in diameter, and the secreting portion of the kidneys was much attenuated, owing to the distention the pelves had undergone. In this latter case the distended bladder, due to an imperforate urethra, had rendered delivery exceedingly difficult.

Hypospadias (ὑπὸ, beneath, σπάω, I draw) is the name applied to that deformity which is characterized by an absence of some portion of the lower wall of the urethra. Usually the portion of the urethra anterior to the abnormal opening is simply a groove with its concavity downward, the misplaced meatus occurring anywhere in front of the membranous urethra. Hypospadias is generally described as of three varieties, though the distinction is made for purposes of description. In the first form the urethra opens at the base of the glans; in the second, at some point between the glans and the peno-scrotal angle; in the third form the scrotum is divided antero-posteriorly along the line of the raphé and closely resembles the vulva, the urethra opening between the lips of the division.

The first form, or glandular hypospadias, appears under numerous varieties; most commonly the deformity consists in an opening into the urethra, beneath the glans, at the spot where the frænum, which is absent, ought to be inserted; the glans is deeply grooved by a sinus, which represents the upper wall of the urethra. It is not very uncommon to see what appears to be a double meatus, the upper one being simply a short *cul-de-sac*, the lower opening, which is often very small, communicating with the urethra. Occasionally the glans is perforated by the urethra, but the meatus itself is closed, and a little fistulous opening is situated at its base through which the urine passes. A case has recently come under my observation in which the frænum, as well as the glans, was divided.

The second form, or penile hypospadias, includes those cases in which the abnormal opening is situated in the penis itself, between the glans and the peno-scrotal angle, but without division of the scrotum. It is the rarest of the three forms, and it is hardly possible to say at what point the opening is most frequent. The size of the ori-

fice is variable. It may be so small as to cause symptoms of stricture, exactly as in atresia of the normal meatus. There may be double openings. The urethra anterior to the misplaced meatus is ordinarily transformed into a gutter by the absence of its under portion. Sometimes the canal is preserved intact in front of the opening, when the deformity might properly be called congenital fistula.

In the third form (the perineo-scrotal) the penis is very imperfectly developed, almost rudimentary, and the urethral opening occurs under the pubes, between the two halves of the bifid scrotum. The inner sides of the divided scrotum are in contact, and are kept constantly moist and reddened by urine, so that the resemblance to a vulva with hypertrophied clitoris is very close. This is the deformity which is often taken for hermaphroditism. The amount of deformity of the penis varies greatly. In extreme cases the rudimentary organ is curved, with the concavity downward. The remains of the urethra form an inelastic band, shorter than the upper portion of the organ which curves around it. The organ is thus doubled and bent in such a manner as to place the glans, which points downward and backward, between the two pouches of the scrotum. This condition interferes very decidedly with erection, and renders the generative function impossible. The urine is always under the control of the will, that is, there is no incontinence. It is ejected with force, but in an improper direction, so that patients are obliged to assume the sitting position during micturition to avoid soiling their clothes. The same condition as to curvature and the effects of the deformity on erection and micturition exists in a modified degree in some cases in the second class, the penile hypospadias. The urethral band is not the only cause of the vicious form of the penis. J. L. Petit[4] gives an account of the dissection of the cadaver of a person affected with hypospadias. He inflated the corpora cavernosa, producing the same curvature described above as occurring during erection, and found the urethra very short and incapable of extension. He separated it carefully from the corpora cavernosa, but in spite of that operation the cavernous bodies lengthened themselves but little, the penis remained curved. Having separated them from all other parts, and drawing upon both ends, he found it impossible to lengthen them. Blowing them up anew they took again the original curve, which he attributed to a ligamentous band which remained at the place from which he had removed the urethra. He separated all of that band possible without opening the corpora, and cut transversely the fibres that he could not remove, in spite of which the curve remained. He then dried the corpora, while still inflated, and afterward cut the one longitudinally, the other transversely, and found that their cells were smallest nearest the urethral side, gradually enlarging toward the convex side, where they were largest. Whether this was the original conformation of the cells, or whether the cells, confined by the urethral band on one side, and comparatively free on the other, had gradually acquired this vicious shape as the result of growth, it was impossible to determine.

The diagnosis of perineo-scrotal hypospadias is not always easy in the young child, especially if, as sometimes happens, the testicles fail to descend and the scrotal pouches are empty. In such cases it is necessary to explore the rectum to establish the presence or absence of the uterus. Errors occur even when the testicles are easily found, if attention is not attracted to them. An interesting example of such a failure to recognize the sex occurred to Tillaux.[5] He was asked to superintend the application of a truss upon a young girl of twelve years. In examining the hernia, which had existed for a few days only, he noticed that the labium majus of that side was a little voluminous. He felt of it, and established the presence of a little ovoid tumor, which he took at first for a little cyst. Instinctively he felt of the other side, and there discovered a similar ovoid body. He immediately asked for a methodical examination, and established the fact that the supposed girl was really a hypospadiac boy. The child had always refused, according to the mother's story, to take part in the amusements proper to its supposed sex.

The treatment of hypospadias differs according to the character and extent of the deformity. I have myself seen one case in which an abnormal opening occurred at the base of the glans; the glans itself was traversed by the urethra, but the meatus was closed and the urine all escaped by the abnormal opening; it was only necessary to establish a meatus at the proper position to cause the hypospadiac orifice to close. Such cases offer little difficulty; but, unfortunately, they are not the most common. When the glans is fissured and the opening of the urethra sufficient, it is not best to interfere. Bouisson[6] is said to have succeeded in correcting the curvature by incising the fibrous envelope of the corpora cavernosa, but the dissection of Petit shows that incisions cannot always succeed. Plastic operations can seldom be of service.

Epispadias consists in a congenital opening, more or less extended, of the upper wall of the urethra. This deformity exists always in connection with extrophy of the bladder, but also occurs when the anterior wall of the bladder is perfect. Epispadias is sometimes spoken of as a first degree of extrophy of the bladder. When vesical extrophy exists, epispadias is a consequence of the more serious deformity, but epispadias alone can hardly be regarded as having any relation to extrophy. Compared to hypospadias, epispadias is rare, in the proportion of one case of epispadias to three hundred of hypospadias. The explanation of the formation of epispadias is by no means simple. A mere arrest of development is not sufficient to explain the situation of the urethra upon the dorsum. Professor Thiersch considers the following three points essential to the malformation: the pelvis closes too late; the urethra proceeds too rapidly and too early forward and above; in consequence of the too late closure of the pelvis the genital tube likewise develops too late, and, therefore, is situated beneath the urethra. According to this opinion the transverse section of an epispadiac penis shows its constituent parts in a reverse situation, the split urethra above, immediately beneath it a rudimentary corpus spongiosum, and the corpora cavernosa lowermost. Bergh, of Copenhagen, has minutely examined and published an account of a case which illustrates this reversal of the different parts of the organ; the dorsalis penis artery ran along the lower surface. Thiersch gives a figurative representation of the condition as follows: Let the tube formed by the back of a small, thick book (back downward) represent the urethra, and each half of the book a corpus cavernosum. Now open the book so widely as to bring the outer surfaces of the covers into contact, and the situation of the tube will be on top. Let the tube be slit on top and the epispadias is complete.

Epispadias may be described as appearing in two varieties or degrees—complete or incomplete; the latter form may be limited to the glans or involve a variable portion of the canal. Complete epispadias is the most frequent variety. The groove is complete, extending from the pubes to the extremity of the glans, though it may not be equally deep and pronounced through its whole length, being deepest toward the pubes. Occasionally a transverse bridle exists just behind the glans, thrown across the urethral gutter like a bridge. The urethral mucous membrane discloses a large number of lacunæ and follicles. The posterior opening often admits the finger. The penis is usually curved upward, and the development of the organ varies very greatly. Incontinence is not uncommon. In some cases in which the power of retention is perfect the stream has little force, though the disturbance of function is less than often occurs in cases of hypospadias. The genital function is usually incompletely or imperfectly performed.

Incomplete epispadias may be confined to the glans, or the superior wall of the urethra may be wanting along a portion of the body of the penis.

Plastic operations for the relief of the deformity have been performed with success.

Double Urethra.—The existence of a true double urethra has never been established save in the rare cases

of double penis. Additional openings upon the glans occur often enough, but they ordinarily communicate with a *cul-de-sac* only. In these cases the lower opening is the true meatus. Occasionally, but rarely, both openings give exit to urine. Vidal saw a subject with three openings; two pierced the glans the third was at the base of the frænum, and was the largest. When the urine was strongly projected it passed through all of the three openings.

There are at least two cases on record of an abnormal subcutaneous passage situated on the dorsal surface and extending from the glans to the symphysis; neither of them communicated with the urethra. One of them showed after coitus a little discharge, which was supposed to be prostatic. In both these cases the abnormal passage was the seat of a gonorrhœa. In the *Annales des Maladies des Organes Génito-Urinaires* for March, 1886, Dr. Louis Poisson, of Nantes, reports, under the name of "double urethra," a case which appears to be unique. At birth the only peculiarity noticed in the subject of the anomaly was a division of the prepuce on the inferior surface forming two lateral flaps. When the mother received the child from the nurse, at the age of eighteen months, she found that he urinated oftener than his older brothers, that the stream was less voluminous, and that the penis swelled on its inferior aspect during micturition. As the infant advanced in age it took him longer to empty his bladder, and the elongated swelling beneath the penis increased in size. Trouble in micturition slowly increased, amounting at one time to complete retention, and finally there formed at the normal site of the frænum a little papule that the mother broke between her fingers, a few drops of pus escaped, and afterward the urine passed through the opening thus made, in a fine but strong stream. Urination was finally confined entirely to this second opening. Examination showed that the upper passage, which had served for micturition for three years, was nearly closed; a probe made its way as far as the perineo-bulbar region and there met an obstacle. Through the second meatus a probe passed easily into the bladder. Two probes introduced at the same time through the separate openings did not touch. The second meatus was enlarged by the surgeon and all symptoms disappeared. There seems to have been a urethra shaped like the letter Y, with the bottom of the letter toward the bladder. The inferior branch gave passage to urine only after the child was three years old and an opening had been established by an abscess. *Abner Post.*

[1] Vierteljahrschrift für practischen Heilkunde, Prag, 1857, B. iii.
[2] Des vices de conformation de l'urèthre.
[3] Gaz. des Hôpitaux, 1858, p. 306
[4] Œuvres completes, edit. 1857, p. 717.
[5] Nouveau Dict., vol. xxvi., p. 487.
[6] Bull. gen. de therap., 1860, vol. lix., p. 349.

PENIS, INJURIES OF THE. Injuries of the penis may vary from the slightest scratch to the entire removal of the organ. Whatever the cause or character of the wound, its gravity will depend largely upon the freedom from injury of the urethra. Injuries involving the urethra are almost sure to bring in their train difficulties due to the cicatricial contraction and gradual narrowing of the passage. Traumatic strictures are among the most obstinate and difficult to control. When the urethra is not involved one element of difficulty and danger in the immediate care of the case is absent, but evil results may show themselves later. Any wound which leaves behind it any amount of cicatricial tissue is followed by serious results, even when the urethra remains intact. If any of the blood-cells of the erectile tissue have been obliterated, a curvature results, whenever the remaining sinuses are filled, which may cause the erect penis to point downward or in any direction. Cicatrices of the integument alone may cause the same faulty position.

Accidental wounds from cutting instruments are almost always transverse rather than longitudinal; when superficial, they are without gravity; when deep, the hæmorrhage may be sufficient to endanger life. Occasionally the dorsal artery is severed and requires a ligature, but ordinarily any hæmorrhage may be controlled by compression.

Lacerated and contused wounds may be occasioned by kicks, falls, blows, etc.

In all cases everything should be done to preserve the organ. Hæmorrhage and urinary infiltration should be guarded against and the wounds treated on general principles. In lacerations of the integuments, if close apposition of the parts is maintained union is generally rapid. Stitches should be used if necessary to retain partially severed portions. Even in very serious injuries there is little risk in trusting to the reparative power of nature, and it is needless to sacrifice much by the knife.

Constriction.—Whenever the penis of a boy is found greatly swollen, a search should be made about its root for a rubber ring or a piece of string which has been tied tightly about the organ. Cases are by no means infrequent in which boys have adopted such mechanical means to avoid the escape of urine which they are unable to control. Rings of other material are also occasionally slipped over the penis. A very slight constriction is sure to be followed by œdema, removal becomes more and more difficult, and when the doctor is consulted the ring is deeply buried in the œdematous tissues, so that the removal of the constricting object is a matter of great difficulty. Punctures and compression may so far reduce the swelling as to make the object accessible, and the point of a bone-forceps or wire cutters may be insinuated beneath the ring if it is metal, or the point of a bistoury or scissors if it is a string.

Gunshot wounds of the penis are not very rare in military surgery, but they are usually complicated with grave injuries of the neighboring parts. Usually gunshot wounds of the penis are said to provoke little hæmorrhage, but they often cause retention of urine. Urinary fistulæ often result, and sometimes, in the course of cicatrization, an obstinate priapism occurs. When uncomplicated, and if the urethra is uninjured, the wounds are not necessarily grave so far as life is concerned. The ball may be encysted, as in a case reported by Dr. S. W. Gross, of a man wounded at the battle of Shiloh, April 7, 1862. Six weeks after the injury Dr. Gross found an ordinary conical ball encysted in the right corpus cavernosum, the point of the missile presenting toward, and being one inch from, the pubes. The patient had not had an erection since the wound, but he had no pain and could not be induced to have the ball removed.

Rupture of the Frænum.—The frænum is often abnormally short, and at the same time too thin and fragile to resist any great amount of traction. In such cases it is often ruptured during coitus, and anyone who examines his urinary patients in reference to that point will be surprised to find how often the frænum presents evidence of a previous rupture. These little tears are frequently so slight as hardly to attract attention, but they are often the spot of syphilitic inoculation—a fact which gives them an importance far beyond their actual surgical value. Occasionally the artery of the frænum is torn across and left in such a manner that it cannot retract, so that it continues to pour out a minute stream of blood. A little snip with the scissors, making the wound a trifle deeper, will usually allow the artery to retract and close; but I have been obliged to tie the little vessel.

Fracture.—Strictly speaking, there can be no fracture of the penis, as neither bone nor cartilage is involved in its structure. The term is, however, applied to the accident which occasionally happens to the erect organ, which might be more correctly described as a rupture or laceration. It is occasioned by the application of force in some manner to the distended organ. It may occur during coitus or from a blow. Eve, in his "Surgical Cases," gives an account of three cases: one occurred during coitus; one was the result of a blow against a bedpost; the third was the result of a forcible attempt made by the patient, while dressing, to put the erect organ into his drawers. The rupture may take place in the fibrous sheath either of the corpora cavernosa or of the corpus spongiosum. The urethra is often ruptured, as is demonstrated by the appearance of blood at the meatus. The result

of an attempt to forcibly and suddenly straighten the painful curve, which is so well known under the name of chordee, and which is spoken of as "breaking the chordee," is practically the same as that known as fracture. The accident is accompanied by a well-marked pain at the place of rupture, which may cause fainting. The pain remains most marked at this spot, but may radiate in various directions, as toward the rectum or anus. As an immediate result of the violence the organ grows flaccid and then swells, sometimes to an enormous size, from extravasated blood.

Patients usually recover, but often with some disability. The organ may lose the power of erection beyond the point of injury, or a nodule may be left behind at the point which causes a curve in the erect organ, or a penile urethral fistula may result. Traumatic stricture must follow the accident in nearly all cases.

Treatment should consist of elevation of the organ on the abdomen, evaporating lotions or ice locally, catheterization carefully performed if necessary, perhaps the tied-in-catheter, and if the tension increases and threatens mischief an incision is preferable to waiting for a spontaneous opening.

Dislocation of the Penis.—Of course a dislocation of the penis is, strictly speaking, impossible, but there are two cases, published by Nélaton and Moldenhauser, on record which are better described under that name than under any other. In this accident the penis appears shortened, one finds in the scrotum or somewhere about the base of the organ an irregular, oblong mass, which is only the displaced penis. The free portion, which is the cutaneous envelope, gives the sensation of a rubber tube containing a fluid mass. This grave condition is due to a violent traumatism and to a mechanism analogous to the pressure which is used to discharge a cherry-stone from between the thumb and finger. The organ must be replaced by making it follow the same route it traversed to bring about the dislocation. If replacement prove difficult it must be accomplished even if it is necessary to incise the skin.[1] *Abner Post.*

[1] Nouveau Dictionnaire de Médecine et de Chir., 26, p. 496.

PENIS, NEW GROWTHS OF THE. The penis may be the seat of various morbid growths and lesions. Many of these deserve little more than mere mention. The article Penis, in the "Real-Encyclopädie der Gesammten Heilkunde," gives a case from Albinus of aneurism of the arteria dorsalis penis, which was opened as an abscess. Varices are occasionally seen, as are also dilatations of the lymphatics. Sebaceous cysts are not very uncommon. Two or three cases are on record of the presence of a bony growth in the penis. Cutaneous horns occasionally occur. In the *Indian Medical Gazette* of January, 1886, is an account of a Hindoo, sixty years of age, who had been circumcised eight months previous for irritation beneath the foreskin, and since that time there had developed two well-marked horny projections, growing from the corona glandis. The surface of the glans was covered with a cap of similar material.

Elephantiasis is rarely seen outside of India and Africa, and is seldom confined to the penis alone. Usually the scrotum is included in the growth. Of 113 cases operated upon at the Medical College Hospital of Calcutta, 3 cases were limited to the prepuce alone, and 1 to the penis.

All the forms of malignant disease occur upon the penis, but epithelioma is the only form that occurs with any frequency.

Epithelioma.—Epithelioma seldom appears before the age of forty, and is probably most frequent between the ages of fifty and sixty. In its general characteristics it corresponds most closely with epithelioma in other situations. It commences usually, but by no means always, upon the glans as a papillomatous outgrowth, but with a broader margin than belongs to ordinary venereal warts, and slowly increases for some time without pain. Ulceration takes place, and a thin, fœtid, bloody fluid is discharged. The growth becomes painful and spreads, destroying some portion of the glans and involving the prepuce. The glands in the groin become involved and the patient dies exhausted.

A very large proportion of cases occur in persons with congenital phimosis, and it is frequently said that phimosis predisposes to the disease, and that the circumcised races are comparatively free. Demarquay found that of 62 cases of cancer of the penis, in 42 there had been congenital phimosis. In some few instances the origin of the malady has been attributed to marital connection with wives suffering from cancer of the uterus, but whether rightly or wrongly, is not certainly determined. The diagnosis is usually easy when cases are presented for advice. The age of the patient, the firmness of the growth, the ulceration and sanious discharge, the tendency to hæmorrhage at the slightest touch, the enlargement of the glands in the groin, with the steady progress of the disease usually leave little doubt as to its character. In some instances the diagnosis between papillomata and papillary epithelioma is difficult; ulceration of the surface indicates epithelioma. There is sometimes a question as to syphilis, the induration suggesting a primary sore; in such a case it would be proper to resort immediately to constitutional treatment, and a short time ought to suffice to settle the matter.

When the prepuce alone, or the skin of the penis, is the seat of the disease, it begins as an indurated nodule, which enlarges and spreads, reddens on the surface, opens, and discharges a thin, sero-purulent material.

The true cancer, so called, also begins in the form of nodules, which extend more and more, and deeper and deeper, and finally ulcerate. Pain and discharge from the urethra accompany the disease; at first the pain is slight and felt only on erection, later it increases and radiates toward the loins and thighs.

The duration of the disease varies very decidedly in epithelioma and in the graver forms of malignant affection. Epithelioma runs a course that varies from a few months to fifteen or twenty years; in the severer forms the maximum duration does not surpass two or three years.

Treatment, unfortunately, is limited to amputation. When the growth is removed at an early date, the prospect of freedom from a return of the disease is good. It is necessary to carefully establish the limit of the lesion to make sure that it has not extended beyond the control of surgery.

Papillomata, or venereal warts, are exceedingly common. The term gonorrhœal warts is often applied, but if by the term any inevitable connection between gonorrhœa and the papillary hypertrophy is understood, the term is a misnomer; nor is there any necessary connection between the warts and any venereal disease whatever. The moisture and hyperæmia of the part caused by venereal or other disease present favorable conditions for the warty growth, but the warts often appear independently of other disease. The warts are very common just behind the corona glandis, but any part, or all parts of both the glans and the internal surface of the prepuce, may be covered. The growths may be pedunculated or sessile. When very numerous they are occasionally bathed in a purulent, foul-smelling fluid. They are usually soft, but occasionally are almost horny. They may be so large and so numerous beneath the prepuce as to cause phimosis, and the pressure of the growing warts occasionally causes sloughing of the prepuce through which the warts protrude. In such a case the slough takes place upon the dorsum. As commonly seen, the papillomata are few in number and are unmistakable. When they cover the whole surface it is sometimes difficult to distinguish them from an epitheliomatous growth. Ulceration of the surface indicates epithelioma.

Treatment.—The destruction of venereal warts may be accomplished in various ways. They may be destroyed by mild caustics. Acetic acid is often effectual, but a stronger application is necessary at times. They may be ligatured; a method which is unattended by hæmorrhage and is moderately speedy, but which is entirely inapplicable to a penis covered with the growth. Absorbent and astringent powders cause them to shrink, and often to disappear.

Calomel dusted on two or three times a day is often very effectual in removing the more delicate growths, but has little effect upon the horny variety. Immediate removal with the scissors is the speediest and perhaps the most satisfactory method, but the bleeding is not always easy of control, persisting in spite of styptics or even the cautery; the little wound behaves in very much the same manner as troublesome leech bites. Pressure, which can usually be applied by putting absorbent cotton upon the wound and then drawing the foreskin over it, is the most satisfactory way of controlling the hæmorrhage. In those cases in which the warts induce a phimosis circumcision is necessary.

Thrombosis (?) of the Corpora Cavernosa. — In an address as President of the Clinical Society of London, Mr. Prescott Hewitt describes what he believes to be a blocking of the corpus cavernosum of the penis, which may take place spontaneously in gouty constitutions without strain or injury of any kind. He gives two cases: The first was in a gentleman, sixty-five years of age, who had shown a decided tendency to gout. He consulted Mr. Hewitt concerning a nodule in the under part of the corpus cavernosum, about an inch beyond the glans. "Of the size of a sixpence, this nodule was hard and perfectly circumscribed; it was without pain, and as there had never been any injury of any kind or sort, it had been accidentally discovered. There were no enlarged glands in the groin. Matters remained much in the same state for a couple of years," when the gentleman died from an accident. In the second case, the gentleman, who was fifty-eight years of age, had also shown in various ways a tendency to gout, and in this case, too, the trouble was accidentally discovered, there never having been strain or injury of any kind. In the corpus cavernosum were four nodules, three on the left side and one on the right side, varying in size from a pea to that of a French bean. They were perfectly circumscribed, hard to the touch, knot-like, and painless when handled. There were no enlarged glands in the groins; the patient had never had syphilis, and he was in good health and of his usual weight. "I first examined the case," said the author, "two years back, and all that has occurred from that time to this is a marked diminution in the size of the nodules, two of them having disappeared, leaving merely a trace of thickening, and the largest being now not bigger than a pea. The groins remain perfectly free, and the gentleman is in his usual health and of his usual weight. The case was left to its natural course." Mr. Hewitt thinks it may fairly be inferred that they were cases of spontaneous blocking, of a gouty origin, in patches, of the corpus cavernosum. Similar cases have been described by other observers.

Abner Post.

PENNYROYAL (American) (*Hedeoma*, U. S. Ph.), *Hedeoma pulegioides* Persoon; Order, *Labiatæ*. This exceedingly fragrant little mint has been so named from the European Pennyroyal (*Mentha Pulegium* Linn.), which it resembles in odor. It is an inconspicuous herb, with small, oblong, ovate, obscurely serrate, opposite leaves, and a few flowered whorls of minute lilac-colored flowers. Calyx and corolla, each two-lipped; stamens, four; two fertile; taste strong and pungent. The entire plant, which is from ten to thirty centimetres high, is collected, and contains a yellow *essential oil* to which it owes its odor and taste.

Hedeoma has, in a high degree, the tonic and stomachic properties of mints in general, it is therefore carminative, and in combination with plenty of hot water, as "mint-tea," sudorific.

Allied Plants.—See Peppermint. *W. P. Bolles.*

PENSION LAWS. Almost all civilized nations regard the discipline and *morale* of their armies of such great importance that they have taken special pains to reward those who are stricken down in their service by substantial and regular grants of money.

The laws of the United States are very liberal in this regard, and as much money is annually disbursed as would suffice for the support of a much larger standing army than we now possess.

The principal body of Pension Laws is of recent origin, dating not farther back than the War of the Rebellion. The country, previous to that time, had granted pensions to its veteran soldiers and sailors but the persons entitled to aid from the Government were comparatively few in number, and the pecuniary outlay was insignificant compared with the amount now paid out.

The principle upon which the legislation in regard to the soldiers of the War of the Revolution and of the War of 1812 is based, is the fact of service rather than that of disability. All soldiers or sailors who served in either of these wars for a period of fourteen days are entitled to a pension of eight dollars per month.

In the case of the War of the Rebellion the laws require a disability from disease or wounds as a pre-requisite to a pension. The regulations in regard to disabilities sufficient to secure a pension have been enacted in a liberal spirit toward the applicant, and have been construed in the same way, so that at the present time the rolls of the Pension Office contain the names of pensioners to the number of many scores of thousands.

An attempt has been made at the recent session of Congress (1886–1887) to extend the principle of granting pensions to the veterans of the Rebellion, so as to include all who served, in addition to those who were disabled, provided the former were now unable to support themselves. A bill to carry out this plan passed both Houses of Congress, but was vetoed by President Cleveland. It has been calculated that the bill, if it had become a law, would have added hundreds of millions to the disbursements of the Pension Office.

The present condition of the Pension Laws makes them of more interest to the medical profession than if the bill had become a law, and inability to support one's self made the condition of a pension, rather than a wound or disease, as is now the requirement. Still it must not be supposed that the pension-rolls contain only the names of those who have been in the service of the United States, and have been injured or disabled by such service. The widows of deceased soldiers are entitled to their pensions, and minor children have the same rights.

Pensions are not subject to the debts of the pensioner, and cannot be reached by an execution.

Briefly stated, the persons entitled to receive pensions for disabilities are officers of the Army, officers of the Navy or Marine Corps, and enlisted men employed in any way in the military or naval service of the United States; masters, sailors, engineers, or other persons not regularly mustered into the United States service, and members of the militia of the several States serving for the time under command of the United States.

The pension-rate for total disability, which means disability such as to prevent a person from earning his living and requiring the help of another person in getting about, varied by the earlier laws between eight and thirty dollars a month. This rate has been changed frequently by Congress, and always in the direction of larger pensions, until now total disability entitles a person to a pension of seventy-two dollars a month.

The laws give fixed amounts for special injuries, such as the loss of both hands, both feet, both eyes, or hearing in both ears, and for the loss of single limbs or organs. The rate now for the loss of both hands, both feet, or both eyes is seventy-two dollars per month.

The latest law, that of August 4, 1886, which relates to the loss of single limbs, provides that the soldier or sailor who has lost one hand or one foot, or has been totally disabled in either, shall receive thirty dollars per month; those who have lost an arm at or above the elbow, or a leg at or above the knee, or have been totally disabled in either, thirty-six dollars per month; those who have lost an arm at the shoulder-joint, or a leg at the hip-joint, or so near the joint as to prevent the use of an artificial limb, forty-five dollars per month. In cases where artificial limbs can be used, they are to be provided by the Government every five years. If the pensioner elects, he can receive money compensation in place of the artificial limbs as

follows: For a leg, seventy-five dollars; an arm, fifty dollars; feet, fifty dollars; and for apparatus for resection, fifty dollars.

When the applicant for a pension has made his declaration of a claim, reference is then had to the records of the War and Navy Departments, to see if they contain any mention of his injury or disease. If they do not, the applicant will be called upon to furnish the testimony of the surgeon by whom he was treated, showing the location and nature of the wound or injury, and the circumstances of receiving it. If the disability comes from disease, the testimony of the surgeon or assistant surgeon should be given, with all the details available. The surgeon should state whether the habits of the applicant had any agency in producing the disease. If the testimony of the surgeon, assistant surgeon, or other commissioned officer cannot be produced as evidence of the origin of the disability alleged, the testimony of other persons having personal knowledge of the facts will be considered. When the applicant has made his declaration, it becomes the duty of the Medical Examiners to investigate the case.

The rules for such examinations are found in the Acts of Congress and the Regulations of the Commissioner of Pensions.

The law of 1882 provides: "That the Commissioner of Pensions is hereby authorized to appoint surgeons who, under his control and direction, shall make such examination of pensioners and claimants for pension or increased pension as he shall require; and he shall organize boards of surgeons, to consist of three members each, at such points in each State as he shall deem necessary, and all examinations, so far as practicable, shall be made by the boards, and no examination shall be made by one surgeon excepting under such circumstances as make it impracticable for a claimant to present himself before a board.

"*Provided*, That the Commissioner may, when in his opinion the exigencies of the service require it, organize a board of three surgeons who, under his direction, shall review the work of any regularly appointed board or surgeon.

"*Provided, further*, That all examinations shall be thorough and searching, and the certificate contain a full description of the physical condition of the claimant at the time, which shall include all the physical and rational signs and a statement of all structural changes."

The fee for such examination is $2 for each member of the board, when the examination is made by a board, and $2 when made by one surgeon. When the Commissioner considers that the degree of disability cannot be determined truthfully or satisfactorily except by expert examination, he is allowed to employ an expert, who is not a regularly appointed surgeon, to make the examination. The fee in such case is $5. Actual travelling expenses of the surgeon who makes an examination of a claimant not able to appear before the board will be allowed.

On the regular staff of the Pension Office are the following officers, with salaries as stated: Medical Referee, $2,500; Assistant Medical Referee, $2,250; four qualified Surgeons, experts in their profession, $2,000 each; fifteen Medical Examiners, who shall be surgeons of education, skill, and experience in their profession, $1,800 each.

The examining surgeons are required to grade the disability of the claimant, except in those cases where the law gives a specific sum for a specific injury. There are three grades of disability, and they are stated as follows in the instructions issued to all examining surgeons:

First Grade: A permanent disability in a degree requiring regular aid and attendance by another person.

Second Grade: A permanent disability in a degree incapacitating claimant for the performance of any manual labor.

Third Grade: Disability in a degree equivalent to the loss of a hand or foot.

Anchylosis of the wrist or ankle is accepted as the type of a disability classed in office parlance as "total," and all minor disabilities are estimated by comparison with it. That is, when a disability exists, from whatever physical cause, the disabling effects of which are as great as that of an anchylosed wrist or ankle, the condition should be designated as "total;" and disabilities existing in a less degree are governed by similar comparisons and expressed in some fraction or fractions of total that will fairly represent them, as one-fourth, one-half, three-fourths. In the case of the third grade, in order to provide for disabilities greater in degree than anchylosis of the wrist or ankle, and less than equivalent to the loss of a hand or foot, the ratings are expressed in eighteenths, as ten-eighteenths, twelve-eighteenths, never as one-fourth, one-third.

The pamphlet issued by Dr. John Campbell, Medical Referee, of "Instructions to Examining Surgeons," contains much that is of interest to anyone investigating the subject of Pension Laws. A few of the specific directions contained in the pamphlet are here given, together with the number attached to them in the pamphlet, thus facilitating a reference.

"27. In the certificate of examination the surgeon frequently concludes his statements with the remark 'We are not willing to make a rating,' or 'We are not willing to increase the present rate.' Such statements imply doubts, and we would suggest that in every case it is the duty of the surgeon to make such rates as are justified by the pathological conditions found, without reference to former rates and without regard to legal consequences, in order that if former rates have been higher or lower than warranted by the degree of disability existing, the pension may be increased, reduced, or, if the disability has disappeared altogether, such pensioner may be dropped from the rolls as provided by law, holding evenly balanced the scales of justice between the pensioner and the Pension Office, without prejudice or partiality to either.

"38. When there is a difference of opinion among the members of a board concerning the merits of a case, and the points at issue are sufficiently important to justify it, the dissenting member will furnish a separate certificate over his own signature, and make a clear statement of the position he has taken, both attached and forwarded in same envelope.

"40. Under no circumstances can the examining surgeon exact or accept a fee from a claimant for services rendered in connection with his claim for pension. The law has provided for the payment of a stipulated fee, and in no case can he accept other compensation.

"41. When a claimant for pension shall request an examining surgeon to make an affidavit in relation to his claim, he should decline to do so; but he should inform him that the Office, upon being notified of the fact, either by himself or his attorney, will, if considered important in the settlement of the claim, call upon the surgeon for such information as he may be able to furnish.

"42. Being a sworn officer of the Government, and acting as agent for this Office, the surgeon cannot permit himself to act in any way as the representative or attorney for any person having a claim pending before it. Neither can he delegate to another the powers that have been entrusted to him. He must himself perform the duties pertaining to his office, in compliance to the terms of his appointment." *Henry A. Riley.*

PENTASTOMA (or linguatula) is classed by Cobbold among the Arachnidæ. The name (πέντε, five, στόμα, mouth) was given through a mistake, the four hooks around the mouth having been regarded as four other mouths. The forms of pentastoma chiefly known to occur in man are larval, viz., *P. denticulatum* and *P. constrictum*.

Pentastoma denticulatum is the young of *P. tænioides*, which infests the nose of the dog. *P. denticulatum* is found in goats, sheep, rabbits, guinea-pigs, etc., and in Germany is often found in man in the liver, lungs, and walls of the intestine. It is found on the surface of the liver as chalky, white, pin-head, crescentic, prominent nodules. In Dresden, in autopsies of persons aged over

twenty years, 5.16 per cent. had pentastoma; in Erlangen, only 1.9 per cent.; men were more frequently affected than women. Frerichs says it is more frequent in the human liver than hydatids are. The *P. tænioides* has an integument covered with numerous sharp spines; the male is one inch, the female three to four inches

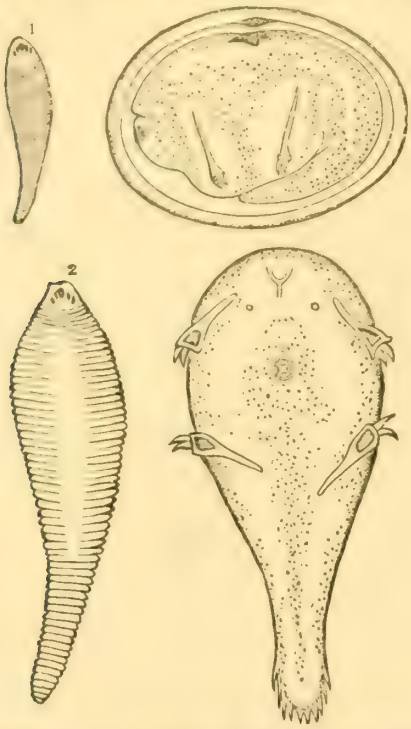

FIG. 2801.—Pentastoma Tænioides. 1, Male; 2, female, natural size; also, egg and embryo, highly magnified. (Leuckart.)

long; the genital opening of the latter is near the tail, while the male genitals are in the front part of the body; reproduction is oviparous. *P. denticulatum* is about two lines in length.

The animal containing the larva being eaten, the latter enters the nostril of the dog or other carnivorous animal making the meal, and there develops into the adult or *P.*

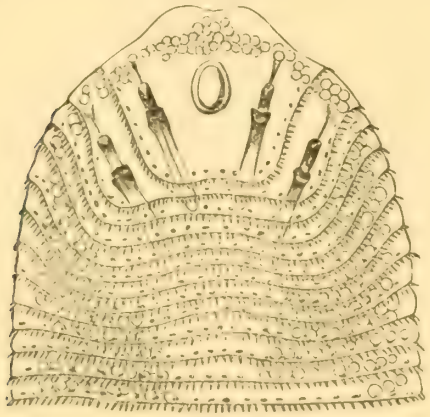

FIG. 2802.—Upper Third of the Body of Pentastoma Denticulatum. Highly Magnified. (Cobbold.)

tænioides, which has "a vermiform, lancet-shaped body, flattened at the ventral surface, attenuated posteriorly, and marked transversely by about ninety rings (Fig. 2802). The cephalo-thoracic segments are continuous with the body, each supporting a pair of strong retractile chitinous claws, four in all. The head is truncated, furnished with an oval mouth, armed with a horny lip." "The adult female measures from three to four inches in length, but the male is only about an inch long" (Cobbold).

"The eggs even before being laid contain fully developed embryos; they escape mixed with nasal mucus. If they reach the alimentary canal of a proper host, their coats are digested, and with their hooks they bore through the intestinal walls, and in some unknown way get into various organs, especially the lungs and liver. There they are encapsulated and develop to *P. denticulatum*" (Heller).

In the *Berliner Klin. Wochenschrift*, No. 49, 1878, Dr. Laudon, of Ebling, says that a man, otherwise healthy, served in the Franco-Prussian War, in 1870, and since then had suffered from repeated epistaxis. At first he had pains about the liver, jaundice, and gastric disturbances. A diagnosis of perihepatitis was made. His epistaxis continued till the early part of 1878, when, during an attack of sneezing, he ejected a worm (which proved to be *Pentastoma tænioides*) from the left nostril.

FIG. 2803.—Pentastoma Constrictum. Magnified four diameters. (After Bilharz.)

Pentastoma constrictum is only known in its immature form. It has been found as a parasite in negroes dying in Cairo, and elsewhere. Aitken, in the Appendix to vol. i. of his "Practice of Medicine," from specimens sent from Jamaica in 1865, describes one of these larvæ found on the pleural surface of a human lung, as being from five to eight lines long, and one line wide, with a compressed head; it had five spots on its anterior surface; its body was rounded, tail end being a blunt cone, and many rings were to be seen on the body, as if the skin were folded.

P. constrictum is eight to twelve times larger than *P. denticulatum*. It has no integumentary spines. The cephalo-thorax has four claws, and it has twenty-three rings; anteriorly it is rounded, posteriorly conical; it is half an inch long, by a line broad. From its greater size there would, of course, be more disturbance caused by its presence than by that of *P. denticulatum*.

Cobbold thinks that *Echinorhynchus* must be one of the above, or some other form of pentastoma, perhaps, in a different period of growth. *Charles E. Hackley.*

PEPPER, BLACK (*Piper*, U. S. Ph.; *Piper Nigrum*, Br. Ph.; *Poivre noir*, Codex Med.). The fruit of *Piper nigrum* Linn., gathered before it is quite ripe. This plant is a climbing shrub, with slender, dichotomously branching, distinctly-jointed, rootlet-bearing stems, from three to six metres long (ten to twenty feet), alternate, short-petioled, ovate, three or more nerved, and reticulated, smooth and shining, bright-green, leathery leaves, and apparently lateral spikes (opposite the leaves) of minute, generally unisexual, achlamydeous flowers. The flowering spikes are very slender (filiform), lax, and drooping, and the flowers themselves, consisting either of a single roundish ovary or a pair of stamens, are embedded in the axes. Berry one-seeded, with a soft mesocarp, a shell surrounding and adherent to the seed, abundant perisperm, and a minute, straight, inverted embryo at the upper part of the seed. It turns red, and finally yellow, as it ripens.

Pepper is a native of Southern India, and possibly has a wider natural range. It is also cultivated there, in other parts of tropical Asia, in the great Oceanic islands, and the West Indies. It is grown in rich soil, where its straggling stems are trained upon poles or the trunks of trees; or they strike root here and there as they run along the ground. The fruits are gathered when they begin to change color, and dried.

This spice has been in use, even in Europe, for more than twenty centuries, and during most of that time it has been a costly and much prized luxury. It was the principal export from India to Europe, values were esti-

mated by it, tributes and rents were paid in it, and the wealth of great cities, like Venice and Genoa, was accumulated largely through the value set upon it. After

Fig. 2804.—Branch of Black Pepper, with Fruit. (Baillon.)

the discovery of the sea-route to India it began to fall in price, and the extension of its cultivation shortly after still further reduced it. At present it is one of the cheaper spices, although one of the most extensively consumed.

"*Pepper Corns,*" as the fruits are frequently called, are "globular, about one-sixth of an inch (four millimetres) in diameter, reticulately wrinkled, brownish-black or grayish-black, internally lighter, hollow, with an undeveloped embryo; aromatic, and having a spicy, hot taste" (U. S. Ph.). Each fruit contains a single seed. A transverse section of Pepper shows a layer of large resin-cells near the surface, and beneath this a soft parenchyme (shrivelled in the dry state) containing starch and oil-drops; the inner portion of the pericarp contains large oil-cells, and the seed shows brownish masses of amorphous *piperin*.

Fig. 2805. — Portion of spike of Black Pepper, showing the sessile and partly embedded flowers. (Baillon).

Composition. — The pungency of Pepper is due to the presence of ten or twelve per cent. of soft, very sharp-tasting *resin*, which is contained, as indicated above, mostly in the cells just beneath the surface. An *essential oil* of clear white color, having the full fragrance of the spice without its biting taste, exists to the extent of one or more per cent. The third and most peculiar ingredient is the neutral, crystalline, tasteless, and inodorous substance *piperin*, which exists to the extent of from two to eight per cent. It was discovered by Oerstedt in 1819. Piperin is scarcely soluble in water, but dissolves moderately well in chloroform, ether, and alcohol; at 212° F. it melts to a yellow, oily liquid. Besides these, starch, mucilage, and albuminous matters are found, as in other vegetable tissues.

Fig. 2806.—Fruit of Black Pepper, Entire. (Baillon.)

Action and Use.—Applied to the skin, Pepper is rubefacient, and finally painfully irritant. It is occasionally sprinkled over the surface of other applications for this effect, but has no advantage over ginger used in the same way. In water it is a popular but painful gargle for "sore throat." Taken internally, it is, in small doses a stimulant, in large ones an irritant to the stomach—that is, it acts like most other spices. It has been given as a specific in the treatment of hæmorrhoids, but is out of use for this purpose. As an antiperiodic it is also obsolete, although piperin is occasionally mentioned in this connection. Whole peppers used to be swallowed for the cure of some cases of dyspepsia. Dangerous symptoms—"rigors, convulsions, and delirium"—have been said to follow its immoderate use (Phillips). Although a typical spice, Pepper is much less employed in medicine than ginger, cardamon, and cinnamon are. On the other hand, its domestic consumption is immense, and probably outranks them all.

Administration.—For dyspeptics or others needing spices, there is no better way than to eat it on the food, or if more is indicated than agreeable to the taste, half a gram (gr. vij.) or less may be given in pills or in a bolus, with honey, two or three times a day; or four or five drops of the *oleoresin* (*Oleoresina Piperis*, U. S. Ph., strength about ⅓) may be taken if a more compact and stronger dose is needed. Dose of piperin half a gram or less.

Allied Plants.—The genus is a very large one, of six hundred species, of exclusively tropical plants, mostly shrubs, and frequently, like the present, climbers. Many of them have pungent fruits. *P. officinarum* Cas., D. C., and *P. longum* Linn., are the sources of "long pepper," which comes in compact spikes one or two inches (2 to 5 centimetres) long, and about a sixth (half a centimetre) in diameter, in which the minute fruits are partially hidden beneath spirally arranged peltate bracts. Its constituents are identical with those of the above, but its flavor and strength are inferior. Long Pepper is never sold at retail in this country, yet it is a common article in wholesale houses; it is probaby used as an adulterant of Black Pepper. *P. cubeba* yields Cubebs, which see. *P. betle* Linn. is an East Indian vine whose leaves are chewed with areca nuts as a masticatory (or a habit) by many aboriginal tribes of the great Polynesian Islands. *P. angustifolium* Ruiz and Pavon, a South American shrub, supplies the Matico leaves formerly used as a styptic in hæmorrhage. The rest of the order *Piperaceæ* is not of much economic importance.

Allied Drugs.—Pepper, Cubebs, and Allspice look much alike. They may be easily distinguished by the smell if one is familiar with them, or Cubebs may be told by the long, peduncle-like base of its pericarp, and Allspice by the four thick, persistent sepals at its apex and its *two* seeds, the others having but one. White Pepper is the fruit of the same plant, *P. nigrum*, allowed to ripen and wilt, and then rubbed between the hands until the outer parts of the pericarp are removed. It contains less of the pungent resin than the black, but is more fragrant in proportion, and is by many preferred for table use. Of other spices and aromatics, many of them the products of the order *Zingiberaceæ*, are nearly related to the Peppers in their properties. Ginger, Curcuma (Curry), Zerumbet, Galanga, etc., are examples, as well as Sweet-flag, in an allied order. They owe their pungency to resins and their fragrance to oils. Less closely related are the drugs containing pungent oils, the true aromatics, like Cardamon, Cinnamon, Cloves, etc.; and still farther removed are the stomachic oils of the Umbellifers and Mints. In the other direction, of excessive sharpness, may be mentioned the anomalous fieriness of the Cayenne Peppers. The *Cruciferous* aromatics, like Mustard and Horseradish, resemble Pepper in some of their effects, but not at all in composition. *W. P. Bolles.*

PEPPER, CAYENNE (*Capsicum*, U. S. Ph.; *Capsici Fructus*, Br. Ph.; *Piment de Cayenne*, Codex Med. The *Fructus Capsici* of the German Pharmacopœia is the Garden Pepper, *Piment des Jardins*, *Poivre de Guinée* of the Codex., from *Capsicum annuum* Linn.). *Capsicum fastigiatum* Bl. is a small, spreading, slender shrub, with

four-sided, pubescent branches, and ovate or lanceolate-pointed leaves. Flowers, two or three together, terminal (?) at the bifurcations of the branches, on erect pedicels slightly recurved at the top, regular, perfect; calyx small,

Fig. 2807.—Capsicum Annuum Linn. (Baillon.)

five-parted corolla, rotate, five cleft, stamens five, inserted upon it. Ovary superior, two-celled. Fruit cylindrical, fusiform, or conical, one or two centimetres (one-half inch) long, and five or six millimetres thick, bright orange-vermilion when ripe, shining. This species is supposed to be a native of South America, but has been for a long time cultivated and naturalized in India, Africa, and other tropical regions.

Capsicum annuum Linn. (in part), is an annual herb, of stouter habit than the above, with solitary flowers on recurved peduncles, and very much larger fruits, of a great variety of shapes. A native of South America, like the preceding, but like that also cultivated and naturalized in most of the warm countries of both hemispheres. It is the common Garden Pepper. It is more hardy than the preceding, and is found in almost a dozen varieties. The use and cultivation of Capsicum followed almost immediately the discovery of America. It appears to have reached Europe first through India, and that so promptly as to make it seem like a native of that country.

The *Guinea, East Indian, or Bird Pepper*, is in small, narrow pods from one-half to five-eighths inch in length, tapering to a blunt point, with a leathery, shrivelled pericarp enclosing two cells, and a number of flat, reniform, yellowish seeds. It has a characteristic odor, and intensely hot, stinging taste.

The *Garden Pepper* is much larger, it may be long and narrow, but other varieties are egg-shaped, pear-shaped, globular, and irregular. They are red or white when ripe, and all have the fiery effect upon the tongue and skin exerted by the first-named.

Composition.—A little *essential oil*, a minute quantity of a fragrant *stearoptene*, some *fat*, and a volatile, not thoroughly studied, *alkaloid*, are among the unimportant constituents. The cause of its intense acridity was discovered by Thresh (1877), and named *Capsaicin*. It is a neutral, crystalline, volatile substance, of the most dreadful acridity, requiring to be handled with great care. That which has been generally regarded as the active principle is *Capsicin*, a purified oleo-resin; it contains oil, resin, capsaicin, etc. Capsicin is a thick, yellowish red substance, scarcely flowing at ordinary temperatures, but becoming very limpid if warmed.

Action and Use.—About the same as those of Pepper (see preceding article). In small quantities, externally, rubefacient, gastric stimulant if taken by mouth, in large ones exceedingly irritating to both skin and intestines. It is an extensively used and useful condiment. "Pepper tea," made from either of these peppers, is frequently used in this country as a gargle in subacute pharyngitis, as a cure for colds, etc. Cayenne is also given in large *boli* (containing from half a gram to one gram) in delirium tremens. The ordinary stomachic dose is three or four decigrams (gr. v. ad viij.).

The following preparations are officinal: Fluid Extract (*Extractum Capsici Fluidum*, U. S. Ph.); Tincture (*Tinctura Capsici*, U. S. Ph., strength $\frac{1}{20}$), and the Oleoresin (*Oleoresinum Capsici*, U. S. Ph., strength about $\frac{1}{4}$). This latter is an ethereal extract with the ether evaporated off. It is a dark, thick, oily liquid, with the odor of Capsicum and an intense taste. Dose: from one-fourth to one drop.

Allied Plants.—See Belladonna.

Allied Drugs.—See Pepper, Black.

W. P. Bolles.

PEPPERMINT (*Mentha Piperita*, U. S. Ph.; *Folia Menthæ Piperitæ*, Ph. G., and *F. M. Crispæ*, Ph. G.; *Mentha piperita*, Codex Med., etc.; *Mentha piperita* Smith, order *Labiatæ*, is a gregarious perennial herb, from one-half to one metre in height, spreading by stolons, and sending up stout, branching, smooth, or slightly hairy, squarish, green, or purple stems. Leaves opposite, petioled, ovate or lanceolate, serrate, dark green, smooth, about five or ten centimetres long. Inflorescence in axillary fascicles, crowded at the ends of the branches into short, rather thick and blunt, spikes.

Flowers small, lavender-colored, slightly labiate, with a nearly regular, bell-shaped, five-toothed calyx, and a tubular or bell-shaped corolla, having the two upper lobes blended into one slightly larger than the others, and emarginate, constituting the upper lip. Stamens four, in the throat of the corolla. Pistil one, four-parted at the base, each lobe containing one ovule. Fruit of four little achenes in the base of the persistent calyx. This mint is easily recognized by its familiar odor, but may also be told from spearmint by its petioled leaves, its compact inflorescence, its darker color, and more robust habit; it is rather variable, and runs into other species, as indeed do many mints. Bentley and Trimen consider it to be a cultivated form of the water-mint, *M. hirsuta* Linn. Peppermint is not known in an undeniably wild state, but the early accounts of it indicate an English origin, and date back nearly two hundred years. It is more or less naturalized in both hemispheres, and is cultivated for its oil in England, France, Germany, and the United States—here, indeed, upon a large and increasing scale; also in India and Australia.

Description and Composition.—The herb has been sufficiently described above. Both leaves and stems, especially the former, have a pleasant, spicy, cooling taste. For final dispensing, the leaves and tops are separated from the comparatively inert branches. Peppermint contains from one to one and a fourth per cent. (Flückiger) of *essential oil*, which is its only valuable constituent. This (*Oleum Menthæ Piperitæ*, U. S. Ph.) is a pale green-

ish or yellowish liquid, becoming darker by age and exposure, of an exquisitely pleasant odor, and an agreeable taste, leaving the mouth hypersensitive to cold. Sp. gr. 0.900. Soluble in an equal weight of alcohol, and in ten or twelve hundred parts of water. It consists of a liquid portion and a crystalline solid (Menthol "Pipmenthol"); the latter can be separated by long standing at a cool temperature, or more quickly by a very cold one (zero F., or below). The menthol of Peppermint is in the market at present to compete with that of *M. javanica* Bl. of

Fig. 2808.—Peppermint Plant. About one-half natural size. (Baillon.)

China and Japan. It has a slightly more delicate odor, but is otherwise similar.

Action and Use.—Peppermint and its oil are, from their taste and agreeable action, the most generally liked of all the mints, if not of all carminatives. This oil is warming and stimulating to the stomach, very seldom irritating. It is a favorite household remedy for nausea, flatulence, and colic; applied to the skin and evaporation prevented, it is a mild stimulant, useful in neuralgia and rheumatism; applied to the forehead and temples it produces a grateful, cooling feeling, with a little tingling that occasionally relieves slight headaches; this property is mostly due to the menthol it contains. The most common employment of Peppermint Oil by physicians, however, is as a flavor, vehicle, or adjuvant of other medicines, especially of cathartics, whose griping it undoubtedly diminishes. Like most mints, Peppermint is frequently used in hot infusion in colds, etc. It is also a favorite flavor for candies.

Administration.—First, of the dried herb, from fifteen to twenty grams may be steeped in a pint of boiling water, but not boiled. Dose, the whole during a half day, in divided doses. Second, of the oil, from five to fifteen drops may be given on sugar, in mucilage (Syrup of Acacia), or otherwise. Spirit of Peppermint (*Spiritus Menthæ Piperitæ*, U. S. Ph.; Essence of Peppermint), the most common preparation, is a ten per cent. solution of the oil in alcohol, in which a little of the dried herb has been macerated for the sake of color. Peppermint Water (*Aqua Menthæ Piperitæ*, U. S. Ph.) is a saturated solution of the oil in water; it is not strong enough for anything but a vehicle. The troches of Oil of Peppermint (*Trochisa Menthæ Piperitæ*, U. S. Ph.) contain about one-fifth drop each. The Mixture of Rhubarb and Soda contains one-third Spirit of Peppermint. The Aromatic Wine, an obsolete preparation, contains a trace of Peppermint flavor. There are, besides these, one or two unofficinal combinations of Peppermint and Soda ("Soda-

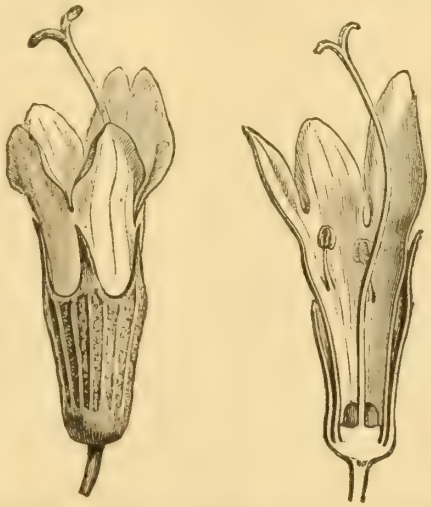

Fig. 2809.—Flower of Peppermint Plant, enlarged; also section of the same. (Baillon.)

mint," "Soda-mint Tablets," etc.) much employed in sour stomach and slight dyspepsia.

Allied Plants.—Spearmint and the English Pennyroyal are of the same genus; so is the Chinese peppermint noticed above, see Menthol. The order is a large one, abounding in oils of similar qualities; the following list includes the more important ones:

Ocimum Basilicum. Basilic, not much used.
Lavandula vera D. C. Lavender.
L. Spica D. C. Spike, "Oil of Spike."
Pogostemon Patchouly Pellet. Patchouly; used in perfumery.
Mentha, several species. Mints. The most important besides Peppermint are Spearmint, and *M. Pulegium* Linn. (*Pouliot commun*, Codex Med.).
Origanum Majorana Linn. Sweet Marjoram.
Origanum vulgaris Linn. Wild Marjoram.
Thymus vulgaris Linn. Thyme, yields thymol.
Thymus Serpyllum Linn.
Hyssopus officinalis Linn. Hyssop.
Hedeoma pulegioides Pers. American Pennyroyal.
Melissa officinalis Linn. Melissa, Balm.
Salvia officinalis Linn. Sage.
Rosmarinus officinalis Linn. Rosemary.
Nepeta Cataria Linn. Catmint.
Leonurus Cardiaca Linn. Motherwort.
Marrubium vulgaris, Tourn. Horehound.
Scutellaria, several species. Skullcaps.

In some of these, like *Marrubium* and *Scutellaria*, the aromatic elements are but slight. The order furnishes many pretty garden flowers.

Allied Drugs.—Besides the above, see Anise and other *Umbelliferæ*, Cinnamon, Ginger, and the other aromatics. *W. P. Bolles.*

PEPSIN (*Pepsinum Saccharatum*, U. S. Ph.; *Pepsinum*, Br. Ph.; Ph. G., not saccharated; *Pepsina*, Codex Med.) An organic ferment (Enzyme) contained in the gastric juice of animals, and capable, in the presence of dilated acids (hydrochloric, lactic, etc.), of digesting proteid (albuminoid) compounds such as albumen, fibrin, and muscular tissue; that is, reducing them to diffusible, non-coagulable substances called peptones. Pepsin, in a state of purity, has not been obtained; its composition is therefore unknown. In a pharmaceutical or commercial sense the name is given to a moist or dry, uncrystallizable substance, containing pepsin, and obtained by solution, or by mechanical means, from the mucous layer of the stomach of the pig, or from the fourth stomach of the calf, sheep, etc., and either offered as nearly pure as possible, or else standardized to some definite digesting strength with starch, sugar of milk, or some other indifferent substance.

Pepsin, in a definite form, is a comparatively recent addition to the materia medica, and was only admitted to the United States Pharmacopœia at the last revision. The use of stomachs to coagulate milk for cheese-making is, of course, of great antiquity, and rennet wine, that is, the cleansed calf's stomach soaked in wine, is no novelty. This and other preparations of rennet, as well as chicken gizzards, have also had some popularity in weak digestion for a couple of generations or more. Dr. Corvisart, of Paris (1854), is said to have been the first to formally propose the use of acidulated pepsin as a medicine. For about twenty years it has been in extensive employment, and during the last half of this time it has probably been sold in greater amount as a domestic remedy than upon physicians' prescriptions.

The gastric juice secreted by the so-called gastric follicles or glands in the stomach, is a clear, thin liquid, with a sour taste and odor, and a specific gravity slightly raised above that of water. It contains from one-half to one or more per cent. of solids. These are salts and other inorganic compounds, albuminous substances, a little mucus, and pepsin. The acid of the stomach is hydrochloric; lactic acid is sometimes also present.

There are several typical methods of preparing pepsin. The simplest, not involving any chemical manipulation, is that of Sir Lionel Beal, and adopted by the British Pharmacopœia. The directions are as follows: "The stomach of the pig, sheep, or calf recently killed, having been cut open and laid on a board with the inner surface upward, any adhering portions of food, dirt, or other impurity are to be removed, and the exposed surface slightly and rapidly washed with a little cold water; the cleaned mucous surface is then to be scraped with a blunt knife or other suitable instrument, with some pressure, and the viscid pulp thus obtained is to be immediately spread upon the surface of glass or glazed earthenware, and quickly dried at a temperature not exceeding 100° F. (37.8 C.). The dried residue is to be reduced to powder and preserved in a stoppered bottle." It should, with a little acid at a warm temperature, dissolve fifty times its weight of boiled white of egg. If well prepared it will do much more. A modification of this method is to separate the mucosa after having cleansed it as above, soak it in cold water, press it, and evaporate the liquid; another method uses acidulated water, by which a larger yield is obtained, which contains, however, considerable peptone. An early process of considerable repute is that of Boudault. The mucous layer of the stomach, separated and cleansed as above, is bruised in a mortar and digested in cold water. The liquid is then separated and precipitated with lead acetate, the precipitate treated with fresh water and subjected to hydrogen sulphide, which separates the lead and allows the pepsin to redissolve; the liquid is filtered and evaporated to a moist condition, and is then mixed with starch. It is a very weak product, the Codex requiring a strength of $\frac{1}{20}$ (*Pepsinæ mediciuale*, Codex Med.); the pure pepsin of the Codex is *Pepsine extractive*, which is required to have the strength $\frac{1}{10}$. It is entirely soluble in water. Pepsin may also be extracted by alcohol; while in strong alcoholic solution it is inactive, but not destroyed, and it becomes active again when the solution is diluted so as to contain only about five per cent. of spirit. An excellent preparation may also be obtained by macerating the prepared stomachs with glycerine. The most generally accepted method, however, is that of Mr. Scheller, of Louisville, Ky., to whose intelligent investigations we owe much of our knowledge of pepsin and pancreatin. This process is to cleanse and separate the lining of the stomachs, then mince them and soak them for a day or two in acidulated water. The liquid is then strained off and treated with an excess of common salt, which precipitates the pepsin as a gray leathery scum, which forms at the top of the liquid. This is pressed nearly dry, redissolved in pure water, reseparated by another treatment with salt, and dried. It is then standardized with sugar of milk. Scheffer's pure pepsin has a marvellous digestive power. Besides these there are innumerable manufacturers of this article now, most of whom have some peculiarity of process or result, and "scales," "granules," "crystals," etc., as well as mixtures with diastase and other ferments, have flooded the market. The only hope of uniformity consists in adhering to some officinal form like that of the United States Pharmacopœia, whose description is as follows:

Description.—"Saccharated pepsin is a white powder of a slight, but not disagreeable, odor and taste, and a slightly acid reaction. It is not completely soluble in water, leaving floccules of pepsin floating in the solution, which, however, dissolve on the addition of a small quantity of hydrochloric acid. Strong turbidity of the acidulated solution indicates the presence of mucus, which also imparts to the saccharated pepsin a disagreeable odor and taste, and will eventually impart to it an ammoniacal odor.

"One part of saccharated pepsin dissolved in 500 parts of water acidulated with 7.5 parts of hydrochloric acid, should digest at least 50 parts of hard-boiled egg albumen in five or six hours, at a temperature of 38° to 40° C. (100° to 104° F.)." The German Pharmacopœia requires a digesting power of $\frac{1}{3}$.

Clear, pure pepsin is not hygroscopic, and does not decompose when exposed to the air, but long exposure diminishes materially its strength. It should not, therefore, be kept from season to season.* Commercial pepsin is liable to contain mucus, products of complete or partial digestion of the stomach tissues, salt, excess of acid, etc. Another peculiarity of certain pepsins should be remembered: that they are active only at a temperature higher than that of the body. These, while scientifically interesting, should be rejected, of course, for medicinal purposes.

Action and Use.—According to Hager's theory, pepsin, as it exists in the glands of the stomach, is in a latent condition, "otherwise it would dissolve and destroy them," and becomes active only by the addition of acid and water. This takes place when it is discharged into the cavity of that organ, and an active compound is immediately formed. He further supposes that the wall of the stomach is here protected from its action by the layer of mucus which covers it. This latent pepsin he has distinguished by the name pepsinyl. His explanation of the action of pepsin is based upon a belief that it has a strong affinity for proteids; that in the gland pepsinyl is a pepsin-proteid compound; this is decomposed in the presence of acid in the stomach, an acid albuminate being formed and the pepsin forced from its relation to take up another portion of proteid material. The acid compound just formed is unstable in the presence of water, its albumen is hydrated into peptone, and the acid

* That time alone does not destroy pepsin would seem to be shown by the following extract: "Two samples of No. 4 (of the same manufacturer) were tested at the same time. One was seven years old, while the other was comparatively fresh, yet their digestive power varied only three grains." Mr. Ch. E. Coombs, who made the above observation, also examined numerous samples of saccharated and "pure" pepsin from the market. He found the former to run generally above the pharmacopœial standard, ranging from 48 to 75, but one sample was worthless. None of the "pure" specimens even approached an ideal strength, the best having only a power of 141, from which they grated down to 86. Pepsins having a power of 1,000 to 2,000 have been prepared.

set free to decompose the pepsinyl again formed, and so on. The explanation is interesting, but not satisfactory. The protection of the stomach by mucus is not sufficient, since it rapidly digests after death, when the mucus must be still there; and if the alternating decomposition processes were the whole explanation of digestion, they ought to go on forever and not come to so quick an end as they do with all accessible pepsins. That pepsin is inactive without acid, and that the process of peptonization is one accompanied by hydration, is pretty well proved, but there are undoubtedly important molecular rearrangements besides. Pepsin acts but little upon the living tissues of warm-blooded animals; it is slightly more energetic with some diseased tissues, like cancer, and still more so with necroses like diphtheritic exfoliation.

The uses of this medicine are foreshadowed above. First and most important is its employment in gastric derangements, for all of which, without regard to kind, it has become, among the more intelligent part of the lay-community, a domestic panacea. The larger manufacturers have catered to this demand, and with a plausible sort of half-scientific method have attempted to adapt it to this wide use by adding other digestive ferments, products of digestion, foods, etc., making generally heterogeneous mixtures of very questionable utility. The real use of pepsin in medicine is difficult to make out. Its chemical action instructs us that it is indicated when the gastric juice is insufficient and albuminoids are not readily digested; when this exact condition of things exists in adults it is difficult to say—certainly not in most cases of dyspepsia; here the digestion is often perfect, or if not, it is intestinal or starchy digestion, and not gastric, that is generally at fault. In extensive cancer of the stomach, where many of the glands are destroyed, in atrophy of the gastric follicles, pernicious anæmia, or interstitial gastritis, it would seem to be most exactly indicated; yet the results in these diseases have not been brilliant. It should be tried in them, however, excepting the first, where there is said to be danger of digesting the cancer and causing perforation. Where a duodenal or jejunal fistula has been made for impassable disease at the pylorus, the albuminoids given through it should be peptonized.

Its external employment in carcinoma of the sloughing form, as a solvent, can be better replaced by curetting, which will accomplish more in ten minutes than pepsin would in a month; its use in diphtheria has never become general. In the digestive disturbances of infants, children with sour, curdy discharges, and similar vomiting, this medicine produces its most gratifying results; here its application is also entirely rational. Besides these, it seems to be of benefit in a good many cases of distress and heaviness after eating, where the digestion is sufficiently good without it, and where the dose given is so small that its digestive power must be unimportant. The explanation of these cases is wanting; perhaps it is that the ingested pepsin is an anodyne, or, as Wood suggests, a stimulant to the stomach. In many of these cases pepsin is not given alone, but with alcohol, glycerine, acid, bismuth, etc., which may take some part in the relief. Pepsin and bismuth are chemically incompatible, yet the best results—results which do not seem wholly explained by the bismuth, are often got by this mixture. Pepsin and alcohol are not incompatible when the latter is reduced in the stomach to five per cent. or less.

Administration. — The saccharated pepsin of this country, usually made by Scheffer's formula, is a slightly acid preparation, and may be given in powder or in acidulated water; the former is the more usual method, the prescriber generally trusting to the natural acid of the stomach. If there is any doubt about the sufficiency of this, the acid had better be added. Glycerine is an excellent solvent and preservative of pepsin, and may be added to any liquid preparation. Alcohol holds pepsin inactive until it is diluted; many of the antiferments destroy it.

The officinal solution of pepsin, a type of many others, is made as follows:

Saccharated pepsin	40 parts.
Hydrochloric acid	12 parts
Glycerine	400 parts.
Water	548 parts.

Wine of pepsin is not officinal here. That of the German Pharmacopœia is as follows:

Pepsin*	50 parts.
Glycerine	50 parts.
Water	50 parts.
Sherry	1,845 parts.
Hydrochloric acid (sp. gr. 1.124)	5 parts.

Mix, and filter after six days.

"Lacto-pepsin" is, according to Hager:

Pepsin (pure)	10 parts.
Pancreatin	7.6 parts.
Sugar of milk	50 parts.
Extract of malt (best)	5 parts.
Lactic acid	2.6 parts.
Hydrochloric acid (25 per cent.)	10 parts.
Glycerine	20 parts.

To which is added powdered tragacanth enough to make pill mass, etc.

Dose.—This important matter has never been settled; about a gram (15 grains) for adults is the ordinary amount; for the relief of dyspeptic distress it often suffices, but for any efficient digesting action three or four times as much should be given; from half a gram to a gram is a suitable dose for small children, the former for those under six months.

Allied Drugs.—Strong acids, water, or steam under pressure, and several other agents, will partly or fully peptonize meats, but need no further mention here. Papaiin and the exudations of *Droseras* and *Nepenthes* have marked digestive power. See Papaw Leaves. Other important and interesting ferments are Pancreatin, Trypsin, Ptyalin, Diastase, etc. *W. P. Bolles.*

PERICARDIUM, INFLAMMATION OF THE. Syn.: Pericarditis; Fr., Péricardite; Ger., Hertzbeutelentzündung.

Anatomy.—The pericardium is a fibro-serous membrane consisting of two layers: an external, or fibrous, and an internal, or serous, layer. The fibrous layer is a dense membrane, attached below to the central tendon and the adjoining muscular part of the diaphragm, and constitutes the chief strength of the pericardium. The superior portion of the pericardial sac is separated into eight tubular sheaths for the great vessels at the base of the heart, viz., one for the vena cava superior, four for the pulmonary veins, two for the pulmonary arteries, and one for the aorta. The serous layer forms a closed sac; the portion covering the heart receives the designation of the visceral layer, while the parietal surface covers the fibrous layer, to which it is intimately attached, and is also reflected over the vessels. The pericardium covers the aorta as high as the commencement of the transverse portion of the arch of the aorta, and covers all the large vessels to an extent greater than is generally imagined. This pericardial membrane sustains the same relations to pathological modifications as do the pleural membranes.

Etiology.—Inflammation of the pericardium may be acute or chronic, the latter process being usually the sequel of the acute affection. Pericarditis, like peritonitis, is almost never idiopathic, although a few eminent authorities admit that it may arise without a distinct cause. It is, on the contrary, usually dependent upon, or associated with, other morbid processes.

The largest number of cases occur in connection with rheumatism or Bright's disease, or as an inflammation propagated from an allied process in contiguous tissues. The sources of inflammation likely to occasion pericarditis by contiguity are: inflammations of the pleura, especially when of chronic type; tubercular processes in the lungs or pleura; inflammation or morbid growth

* Of digesting strength $^{100}/_{1}$; twice as much of ours would be required.

in the mediastina or lungs; inflammatory processes beneath the abdominal diaphragmatic surface, such as peritonitis, perihepatitis, abscess, or other inflammatory processes in the liver. Pericarditis may be secondary to the zymotic diseases, as scarlet fever or variola, or its antecedents may be enteric fever, scurvy, or any of the forms of pyæmia. Pericarditis may be traumatic, or secondary to blows upon the chest, or falls, or contusions of the præcordial region. It may also be developed from wounds inflicted from without or through the œsophagus within. Buist[1] and Flint[2] record instances in which a plate, with artificial teeth attached, became lodged in the œsophagus, and finally penetrated this tube, producing fatal pericarditis.

In rheumatism pericarditis may occur early, occasionally preceding the joint affection, or occurring within the first week of the onset of the rheumatic attack; though no period of the disease can be regarded as free from the so-called complication. Neither the severity of the rheumatic attack nor the number of joints involved has any direct relation to the pericardial process. Pericarditis does not occur in chronic rheumatism, and its relation to gout is doubtful, for although Flint records a case in which the joints were found after death incrusted with urate of soda, the kidneys also were contracted. In a variously estimated proportion of cases both endo- and peri-cardial disease exist. Pericarditis may occasionally be secondary to fibroid disease of the walls of the heart, although more commonly it is true that pericarditis may be the antecedent of cardiac fibrosis.[3] In renal disease pericarditis is usually a late phenomenon, and it is very often an indication of impending uræmia. Acute alcoholism sometimes is the cause of pericarditis, and, in general, it must be borne in mind that the debilitated, the poorly nourished, the young, the old, and those living in unhygienic surroundings are most exposed to pericardial inflammation.

Pathology.—In pericardial inflammation the process may be associated with fibrinous or serous effusion. The early appearance of pericardial inflammation is rarely seen. The writer has made post-mortem examinations thirty-six hours after the pericardium had been injured by penetrating wounds, and has found purulent exudation. If the pericardial inflammation is fibrinous, plastic lymph, more or less moistened with serum, is distributed over the pericardial surface in flakes which are more or less thickly massed at some points, while at others the pericardium may be normal; there is also a variable amount of fluid effusion in which flakes of fibrine float. In the initial stages of the process there is repletion of the pericardial capillaries on both the costal and visceral layers of the pericardium. Vascular projections or vegetations form, over which, if the process proceeds to exudation, the lymph is most thickly coated. The serous surface of the pericardium presents a soft, red, velvety appearance, or the villi may look pale and turbid, as if infiltrated. The epithelium is shed in patches between which intact epithelium may be found, and minute granular reticulated masses of lymph are poured out between the remaining epithelial cells. The epithelium may become homogeneous and granular—that is to say, it undergoes coagulative necrosis, and when there is very little serous fluid is known as dry pericarditis. If there is some exudation it may be small in quantity, fibrinous pericarditis; or there may be abundant sero-fibrinous exudation, sero-fibrinous pericarditis. In the first form the membrane is generally much reddened, the surface has lost its lustre and become opaque, an appearance which is very marked in the transverse furrow, but may be circumscribed about the roots of the great vessels, or involve the entire visceral and parietal pericardium. The whole surface of the heart may be covered with a thin fibrinous layer, which may, even at this early stage, have formed adhesions connecting the visceral and parietal layers of the pericardium. It is more developed on the parietal layer, but in some few cases coagulable matter is found in larger quantities in the serous portion of the effusion, and appears in the form of roundish or flattened free bodies, about the size of a bean or hazel-nut, and generally forms a net-work between the heart and pericardium, to both of which it adheres. The serous effusion may be only a few ounces, or several pints; it is always turbid from molecular fibrine suspended in it, and may be yellowish-green, brown, or red in color. The pericardial exudation is usually sero-fibrinous in character; it is rarely sero-albuminous. When it is small in amount it will gravitate to the most dependent portion of the pericardial sac, but when it is large in quantity it may cause enormous distention of the pericardial membranes.

The inflammatory processes in the pericardium are especially characteristic in their later macroscopic appearance. The normal pericardial fluid may coagulate on exposure to air, so that this fact alone is not significant of inflammation; but when the effusion is chiefly fibrinous and considerable in amount, the exudation assumes a characteristic form in consequence of the cardiac movements. Warty and villous projections of varying height cover the pericardial surfaces, particularly on the inferior walls of the heart; frequently ridges are prominent, especially anteriorly, over the origin of the pulmonary artery.

Laennec has compared the appearance of the pericardial surfaces to that presented on suddenly separating two smooth pieces of wood between which a small piece of butter has been forcibly compressed, and the appearance of the pericardium in this stage of the process has been described as the cor villosum, hirsutum, or tomentosum. In many cases the roughness is so prominent that it may be appropriately compared to the appearance presented by the dorsal surface of a bullock's tongue.

When pericardial inflammation complicates Bright's disease, as a rule, comparatively few lesions are found. Smooth, opaque, pearly white, milky patches, often found, particularly on the surface of the right ventricle, have been considered as having an inflammatory origin; they consist in a slight thickening of the serous membranes. If the new formation is more abundant it may take the form of thick, almost cartilaginous, plaques or patches, or of diffused tendinous or scar-like thickenings.

Hæmorrhagic pericarditis is rare, except in purpura, scurvy, tuberculosis, or malignant disease. It is due to the rupture of some of the newly formed fine capillaries which are developed in the fibrinous exudation. The pericardial membrane, or any deposit of lymph upon it, or the fluid exudation, may be deeply stained with blood. Hæmorrhage into the pericardial sac may also occur by rupture of the heart or great vessels. In these cases the blood coagulates in large masses, which may envelop the heart. The presence of fluid blood is an indication of injury to the intra-pericardial blood-vessels.

Suppurative pericarditis may occasionally be primary, or the sequel to an acute pericardial effusion, but is more frequently secondary to traumatism, to empyema, to suppurative mediastinitis, to caries of the ribs, to gangrene of the lungs; or it may be metastatic.

Putrefactive changes may take place in the pus in certain cases of pyæmia, or when in the operative treatment of pericardial effusion antisepsis has been imperfect and air carrying morbific germs has been admitted. Air may also enter the pericardial sac from the œsophagus, stomach, intestines, or lungs, when adhesions to the viscera have been followed by perforation of the pericardial sac.

The tubercular form of pericarditis resembles the similar inflammation observed in the pleura. The tubercular formation is scattered along the course of the vessels, and as it may be associated with fibrinous or hæmorrhagic inflammation, these masses of exudation should be detached and the condition of the subjacent pericardium examined; cheesy nodules of tubercular character are not large in this situation.

The pericardial process may result in more or less extensive fibrinous adhesions between the two surfaces of the pericardium, but these are less common than in the pleural cavity. The entire surfaces of the pericardial sac may be fused so that the pericardial cavity is obliterated. If pus-cells have been numerous in a fibrinous

exudation, masses of cretaceous nodules may be found as the result of calcification of cheesy matter, and thus bone-like masses may form in the midst of fibrous adhesions.

The post-mortem examination of a case witnessed by the writer may serve as a general illustration. The pericardium was firmly attached over the right ventricle for an area of three inches laterally and two inches from above downward and posteriorly. The left ventricle was adherent from the base to the apex by bands of lymph between the costal pericardium and its visceral layer. There was also a broad band of lymph binding the aorta to the costal pericardium, but not attached to the heart at all. This loop acted as a sort of bridle, and was the cause of a marked murmur during life. The pericardium contained three ounces of fluid, and the heart weighed sixteen ounces, and showed eccentric hypertrophy of the left ventricle. There were no marked endocardial lesions.

Fibrinous strings of lymph, similar to that just described, may persist and occasion friction-murmurs long after the process of pericardial inflammation is past. When there are extensive pericardial adhesions the muscular tissue of the heart is gravely affected. Dilatation of the heart, especially of the right and left ventricle, with hypertrophy, may occur. The hypertrophy and dilatation usually affect *both* ventricles, and may be so considerable that the gross weight of the heart may reach two pounds. The action of the heart is seriously crippled by these pericardial adhesions, notwithstanding the increased power acquired by the cardiac muscle. It is a mooted point between writers as to whether the hypertrophy in this connection can occur independently of any valvular lesions. Chevers, Barlow, and Hope are ranged on the affirmative side, and my personal experience at the post-mortem table would incline me to share their view. The experience of Stokes, Sibson, Balfour, and others inclines them to the negative view.

Pericarditis may induce fibroid disease of the heart, and especially in connection with cases of syphilis with visceral lesions.[4] If the circulation through the coronary arteries be interfered with by adhesions, either influencing the circulation through them directly or by modifying the aortic systole, fatty degeneration or dilatation of the chambers of the heart may ensue. Pericardial adhesions are possible at a very early age. Behier reports a case of chronic pericarditis in an infant of eleven months.[5] An adherent pericardium occurring in early life may prevent the growth and development of the heart, and when, as has been already observed, a wall of calcareous encasement of the heart has emanated from chronic pericarditis, a local or general thin fibrous condition of the muscle occurs, and in this manner local or general aneurismal dilatation of the cardiac muscle may be developed. These conditions are, however, rare.

Carcinomatous growths of a primary or secondary character are infrequent in this locality, and the same may be asserted of primary sarcoma, for although this form of morbid growth is the most frequent of those which originate in the anterior mediastinum, Kahnlich,[6] who describes thirteen cases originating in the connective tissue of the anterior mediastinum, and five from the periosteum of the sternum, states that but one arose from the pericardial tissue. In mediastinal sarcomatous disease the pericardium is frequently secondarily invaded. Pericarditis may be secondarily excited by morbid growths occupying the posterior mediastinum, or may be secondary to any form of mediastinal inflammatory process.

Symptoms. — Pericarditis is one of those diseases in which it is necessary to closely consider the etiology or predisposing causes, in order to assist in interpreting the symptoms, although the physical examination of the parts involved is the only method capable of yielding definite information, and is absolutely required before a positive diagnosis can be made.

The majority of cases of acute pericarditis, in connection with rheumatism or Bright's disease, develop insidiously; occasionally the onset may be marked by irregularity of the heart's action. This irregularity is commonly transient, and disappears after the exudation commences to form. Discomfort arising from shortness of breath is less frequent in the formative stage than in pleurisy, but in the stage of even moderate effusion the dyspnœa is marked. The patient is usually more comfortable propped up in bed, or tosses anxiously around, usually inclining the body forward and toward the right side. The subjective sensation of pain is uncommon, yet both pain and tenderness may be recognized. The temperature cannot be reckoned as characteristic; when delirium, with more or less stupor and high temperature, complicates rheumatism or Bright's disease, pericarditis may be suspected. When pericarditis complicates diseases of the pulmonary parenchyma, such as pneumonia of the apex, delirium is frequently present, but is rather an associated symptom of the pulmonary process. Gastric irritability may be prominent. The duration of pericarditis in connection with renal diseases may be transient, and therefore it becomes all the more important to make an early study of the physical signs in suspicious cases. When the effusion is formed, the general and subjective symptoms vary in proportion to the amount of effusion. When the effusion is considerable, the pressure exercised by the distended pericardial sac upon the left lung and the bronchial tubes may be so great as to occasion much respiratory distress. In these instances the posture is significant. It is difficult for the subject to rest in the recumbent posture, but the upright or semi-upright attitude must be maintained, or the prone position, usually on the right, but occasionally on the left side, possibly with the face downward, may be assumed, so that the movements of the dorsal portions of the chest may be the more free. The sense of dyspnœa is present under these circumstances, and the embarrassment of the circulation through the direct influence of the effusion upon the cardiac movements, or by means of the pressure upon the pulmonary system, may heighten the sense of dyspnœa to orthopnœa. Owing to the adaptability of the respiratory organism to the most serious embarrassment, these general symptoms may pass away even in cases in which the effusion persists.

The physical signs are varied, but especially centre in the results of auscultation. In the primary stages of pericarditis, or throughout the history of cases in which the exudation is fibrinous, a grazing, rubbing, or creaking sound may be audible. It is a controverted point, which can never be satisfactorily settled, whether a friction-sound can occur during the first stage of inflammatory dryness of the pericardial membrane, preceding the exudation. It would seem that some exudation must be present before the friction-sound can appear. It is, however, true that a friction-sound may be well defined during life in a case in which an autopsy will reveal scarcely any lesion (Pericarditis Sicca, Walsh), and this is especially the case in the pericarditis associated with pleurisy. Hayden writes: "I have never met with a case which would warrant me in asserting that a state of simple dryness and vascularity of surface may give rise in the pericardium to a veritable friction-sound. I do not, however, deny the possibility of its occurrence; . . . but in every instance, without exception, in which I have had the advantage of determining, by post-mortem examination of the body, the condition of the serous surface of the pericardium where friction-sound of indubitable pericardial origin had existed during the patient's last illness, I have found lymph in greater or less quantity effused upon the surface."

The quality of the pericardial friction-murmur may be soft or blowing, so closely resembling the valvular murmurs that they cannot be differentiated by the acoustic character of the murmur alone. The friction-sound may be a very transient sound. Walsh says it may appear and disappear in six hours. The disappearance of the sound may be due to an increase in the effusion, and it may reappear during the stage of absorption, and finally vanish gradually. As a rule, the friction-sound is audible for several days, and even when the liquid effusion is large, a friction-sound may be recognizable throughout its duration. A friction-sound is sometimes audible in subacute

of chronic pericarditis, but in these cases more or less complete adhesion of the pericardial surfaces will have occurred. Pericardial friction-murmurs commonly occur synchronously with the movements rather than with the sounds of the heart; they may be rhythmical, with one or the other sound, or possess a to-and-fro character described by Watson. The location of the maximum intensity of valvular murmurs at certain places at which the valves are placed closest to the ear of the observer, and their transmission with maximum intensity on definite lines, form conspicuous characteristics of murmurs indicating valve-lesions. The peculiarities of pericardial friction-sounds are chiefly the rapid change of location of their foci of maximum intensity, owing to the liability of one mass of lymph to be polished smooth. The murmur may reappear in a new point in the præcordia, because roughness from a new accumulation may occur in the pericardium elsewhere. Friction-murmurs are not transmitted beyond the cardiac area, except in rare instances. The most common location of friction-murmurs is over the base of the heart or near the origins of the great vessels; yet the frictions may be audible at the apex or at any point of the præcordia. Pericardial frictions are superficial sounds; the valvular murmurs are heard as though developed on a deeper plane. Change of posture may induce an increase of murmur, rendering a murmur which is faint in the vertical position quite distinct in the recumbent. Unless endocarditis be associated, the alterations which are common to the walls of the different chambers of the heart in endocardial disease are absent. It is always desirable to notice the effect of respiration on a possible pericardial friction. Full inspiration tends to intensify pericardial murmurs, especially those audible at the base of the heart. At the apex a friction-sound may be best detected when breathing is suspended after full expiration.

When the effusion is large and composed of serum the sounds of the heart, especially the first, are very faint and muffled, sometimes almost inaudible; but if the effusion is not too large, or is more fibrinous, the sounds of the heart may be clearly heard over the position of the apex-beat, which is usually displaced upward.

Inspection, in instances of acute pericarditis, especially in the young, often discloses prominence of the whole præcordia. The intercostal spaces also may be filled out, the impulse of the heart displaced upward, the sounds growing louder as the stethoscope is carried upward. The character of the impulse may be little changed in this new position, or it may be feeble, weak, or fluttering. Friction fremitus may be recognizable over the præcordial space, or in one of the interspaces of this region. This fremitus often produces a wavy vibration, distinctly visible over the surface of the chest, especially marked in thin persons. The attitude in pericarditis is occasionally striking. The subject may desire to be propped up in bed, or, at all events, the recumbent posture is unpleasant. The patient may toss to one or the other side, or incline the body forward. The right side is frequently chosen in these circumstances, since the liver does not become a source of pressure on the pericardium, and the inclination of the heart to the right side, so far as it is free to move, leaves the largest possible share of space to the pericardium. In many cases however, there is no change in the attitude. As the effusion increases, the foregoing physical signs become intensified. The præcordial prominence becomes conspicuous, the impulse is lost, and the fremitus is absent, except around the vessels at their origin from the ventricles. During the stage of absorption the first-named physical signs, one or all, reappear.

By palpation in cases of pericardial effusion the signs revealed by inspection are confirmed. The patient's body should be inclined forward; this manœuvre will render the apex-beat more easily recognized. As the fluid diminishes or increases, the apex-beat may become more or less apparent. Friction fremitus may be recognized in acute or chronic pericardial disease, and is a very valuable sign of the process, although it is absent in a great many cases. The fremitus can be recognized, if the examination is made in the early stages of acute pericarditis with moderate effusion, accompanying either the systole or diastole, or both; in the latter case the fremitus has a to-and-fro character; the fremitus occurs when the exudation is rich in fibrine, and the flakes are spread over the surface of the pericardium, especially near the base. At an autopsy the particles of fibrine appear like down or fur, covering the heart. The friction of the heart's action frequently masses these particles, giving the condition which has been compared in post-mortem to a bullock's tongue. In order that pericardial frictions may be recognized, the amount of fluid must not be so great as to separate the heart from the chest-wall, and they are more distinct when the body is inclined forward, in which case even feeble cardiac pulsations can produce a definite rub. When pericardial fremitus or friction-sound can be recognized by palpation a murmur can also be detected by auscultation, but the converse is not always true.

The pulse of pericarditis is not characteristic, and is of value only in connection with other signs. Walsh calls attention to the sudden variations in the pulse-rate in pericarditis; a slight movement may increase the pulse from 60 to 90, or 140, just as a similar sudden rapid action of the heart occurs from neurosal or emotional causes. The pulse may be irregular in force and rhythm, as a very early symptom, before sufficient fluid accumulates to interfere with cardiac action. Indeed, after the first twenty-four or forty-eight hours the regular action of the heart may be spontaneously resumed.

Percussion.—The results of artificial distention of the pericardium after death, as obtained by Rotch, of Boston, seem scarcely in consonance with clinical observation. When that observer injected a small amount of fluid into the sac, percussion gave an increase of præcordial flatness; beginning at the sixth rib, about two centimetres to the right of the sternum, it passed upward in a curved line, with the convexity outward, to the fourth right costal cartilage at its lower edge, then across the sternum to the upper border of the fourth left costal cartilage, and outward and downward to, and to the outside of, the nipple, passing down to the sixth or seventh rib. There was no vertical increase of flatness. When a large amount of fluid was introduced, the area of flatness was increased in similar outlines, viz., there was a much greater lateral increase from the upper border of the sixth rib to the lower portion of the third interspace, both to the right and to the left of the sternum, than above the third rib. The vertical dulness was not materially increased. Clinical cases, however, certainly occur in which the contour of the area of cardiac dulness is altered vertically as well as transversely. During the dry stage, however, unless a very considerable amount of lymph be extravasated, the natural percussion dulness in the cardiac region is not appreciably altered. In health the area of cardiac dulness in the adult rarely exceeds three inches transversely at the fifth interspace. If, in percussing from above downward, an area of positive dulness exceeds this limit, or extends above the third rib, it becomes an evidence of pericarditis. The outline of præcordial flatness is a blunt cone; the area of flatness may commence below at the sixth or seventh rib, and possibly extend as high as the first or second rib, and in consonance with Rotch's experimental evidence the transverse area of flatness may extend for an inch or more from the right border of the sternum and to a variable distance beyond the plane of the left nipple. The transition from the outline of flatness to the outline of resonance is abrupt, just as in pleural effusions. The edge of the lung, which normally overlaps the cardiac area, is pushed aside and the area of impaired resonance is lessened. The percussion-note is really flat, not dull, and the resistance to the fingers in percussion is most perceptible.

The amount of a pericardial effusion varies, within comparatively short intervals of time, from day to day: sometimes from morning to evening advances or recessions of dulness can be defined. A very important aid to the diagnosis of this condition is the change of the area of flatness when the position of the patient is changed from side to side, while at the same time auscultation or pal-

pation will show an unchanged apex-beat. Further, examination in the recumbent position may give a clearer percussion resonance over the præcordial area, and the line of transition will be less abrupt as the lungs return to the position from which they were displaced by the fluid. In exceptional cases the dulness may extend on the left side backward almost to the spinal column, and across the sternum to the right nipple. Percussion may assure us that there is fluid in the pericardial sac, but it must be remembered that effusion in this situation may occur as a passive dropsy as well as an inflammatory effusion. Passive dropsy, however, occurs in this situation only together with other passive effusions.

The lesions of chronic pericarditis are very similar to those of chronic pleurisy: 1. The effusion may remain without tendency to increase or to diminish. 2. Adhesion or agglutination of the pericardial surfaces may occur. 3. Retained pericardial effusion may become purulent. The first class of lesions requires no elaboration, since the physical signs of an effusion are always the same, and there are no more certain evidences of purulent pericardial effusion than exist in similar pleural collections. The second condition presents one of the hard problems for clinical study. The diagnosis can be made only when the most unequivocal history can be obtained, and when the most critical examination of the physical signs is instituted. In subacute or chronic forms of pericarditis with adhesion, the general symptoms are those which would naturally follow impeded cardiac action. Dyspnœa of the form peculiar to cardiac disease, that is, increasing on exertion, may be a sign of chronic pericarditis with adhesions, provided that a careful study of the case excludes any other form of cardiac or pulmonary disease, or any neurosal disturbance of the heart. A constant sense of discomfort is recognized, which is referred to the heart, but without a physical examination of the præcordia these symptoms cannot become intelligible.

In hypertrophy or dilatation connected with pericardial adhesion the heart's apex may pulsate in the fifth interspace or higher, in spite of the physical signs of hypertrophy revealed by auscultation, inspection, and palpation; or the heart may be drawn upward and the left ventricle tilted outward and to the left. This position of the left ventricle contrasts markedly with the physical signs of hypertrophy and dilatation without adhesion. The right ventricular dulness also extends in many cases to the right of the sternum. The *sounds* of the heart may, however, be *feeble* in proportion to the strength of the impulse.

It is also a noticeable clinical fact that, when valvular lesions of the heart are combined with extensive pericardial adhesions, the ordinary changes in præcordial dulness which commonly accompany the valvular lesions do not exist, but instead there is an upward cardiac displacement, and those symptoms of venous repletion which must attend crippled propulsive cardiac power do not yield to treatment as readily as might be expected.

If the pericardial surfaces are extensively united the præcordia may be depressed, and the interspaces may be drawn inward during the systole. The heart's apex may be markedly displaced upward and outward, and even the lower portion of the sternum may be contracted. The limits of cardiac dulness are not only enlarged, but the boundaries of cardiac dulness are unchanged by varying postures, or on full inspiration and expiration. There may be no change in the rhythm of the heart, or there may be a very great alteration in rhythm, including irregularity. Walsh states that the systolic dimpling of the interspaces only happens if there be, in addition to pericardial adhesions, pleuritic adhesions in front of the organ, or if the agglutination of the pericardium be combined with extensive cardiac hypertrophy. Dimpling of the interspaces and the wave-like vermicular tremor of the interspaces over the præcordia also occur in individuals whose chest-walls are much emaciated; also if this thinning of the chest-wall be combined with a condition of enlargement and dilatation of the heart, but without pericardial adhesions. It must be also borne in mind that the intercostal tissues may move inward when there is pressure on the bronchial tubes, or obstruction of the same with atelectasis, as may occur in the capillary bronchitis of children; also in some cases of chronic fibroid phthisis, and when extensive pleural adhesions exist; and finally, the symptom is present in many cases of pulmonary emphysema. Therefore, when inspection of the præcordia discloses any vibration, too much importance should not be ascribed to this symptom, unless other physical signs are associated.

Diagnosis.—In making the diagnosis of pericarditis the etiological relations of the disease become of the first importance, because pericarditis is not an idiopathic affection. One source of error in diagnosis is the possibility of mistaking a dilated fatty heart with feeble heart-sounds for the enlargement of the præcordia due to pericardial effusion. There are certain details which separate the flatness of pericardial effusion from the dulness of an enlarged heart. The first of these relates to the change of præcordial contour in pericarditis, elsewhere described. The line of transition from flatness into resonance is more sharp in pericarditis with effusion than in cardiac degeneration with dilatation. Respiratory percussion on full inspiration may be made available to define more sharply the line of transition from resonance to flatness. In cases of simple enlargement of the heart, the area of cardiac dulness is diminished by the use of this method. Dilatation of the heart has a chronic history and is associated with venous stasis, while pericardial effusion begins suddenly and is secondary to other pathological processes.

Large pericardial effusions may extend so far into the axillary region and compress the lung to such an extent as to simulate a pleural effusion. In differential diagnosis one may observe that the physical signs of this latter disorder can be noted in the back, all the way round to the vertebræ, while in large pericardial effusions the gutter on the side of the spinal column will furnish resonance. On the other hand, sacculated pleurisy located anteriorly may simulate the pericardial effusions, but the position of the collection will best serve one when contrasting the symptoms.

Another source of error consists in the confusion of pericardial with pleuro-pericardial effusions. Friction murmurs can be developed in the pleura adjacent to the inflamed pericardial sac by the movements of the heart, if the former be also covered with lymph. One of the best methods of differentiating this murmur from one developed within the pericardium is to cause the patient to cease breathing for a moment, and then to auscultate the heart; the murmur persists if it is pericardial. If the portion of the pleura adjacent to the pericardium be roughened by a coating of lymph, the movements of the normal heart transmitted through the pericardium may produce pleuritic frictions even while the lung is at rest. This murmur is often perceived near the apex of the heart; it may not occur with each cardiac pulsation, and may cease during full held expiration. In addition, one should review the characteristic features of pericardial friction murmurs, and contrast them with the pleuro-pericardial. Pleuro-pericardial frictions have a fixed area of maximum intensity—not a variable one as in pericarditis—and the intensity of the sound varies in pericardial more than in exo-pericardial murmurs. The location of the murmur at the border of the pericardium, and its transmission beyond its confines, will be one of the best aids to auscultation, because in true pericardial frictions, without associated pleural involvement, the murmur will probably be confined within the normal limits of the cardiac area. Walsh refers to a friction which is diastolic in rhythm, produced by the pulsation of the aorta or an exo-pericardial friction between the aorta and the pleura. The diastolic rhythm and the increase during full inspiration may help to establish the identity of this murmur. The diagnosis of pre-existing pleurisy by means of the usual signs of this affection may throw light upon some perplexing murmurs, and the question of the etiological probabilities in regard to the existence of pleurisy or pericarditis may be reviewed.

Pericarditis may be combined with endocarditis. How-

ever much the pericardial murmurs resemble the endocardial, the latter can be recognized by the depth of the plane at which they are developed, by their transmission in the route of the blood-current, and by their being associated with definite enlargements of the cardiac muscle corresponding to the various chambers of the heart. The friction-sound may disappear suddenly on account of the rapid accumulation of a pericardial effusion, but usually the fluid, following the laws of gravitation, seeks the most dependent portion of the sac, which it more or less fully distends; the friction-sound consequently disappears first at the bottom of the sac and at the apex of the heart, and last of all at the base. The friction-sound may never disappear from the base of the heart, even in cases of very large effusion (Balfour), and it may even be transmitted to the apex in rare instances—a circumstance which is obviously confusing if paracentesis is contemplated.

Palpation will usually in a measure confirm the results of auscultation.

In acute, subacute, or chronic pericarditis, local or general adhesions of the pericardial surfaces may modify or prevent the formation of a friction-sound. The vermicular vibration of the interspace over the præcordia, or the displacements of the heart, may enable one to form a conception of the mobility of the heart and the extent of the adhesions. It must, however, be remembered that in thin persons the vermicular movement of the præcordial interspaces can be recognized in cases of pericarditis without adhesion, and even in some individuals without pericardial disease, so that this physical sign possesses only a relative value, and must be combined with some displacement of the heart, or bulging or retraction of the præcordia. Occasionally when the pericardial effusion accumulates quickly, the respiratory distress and embarrassment of the circulation are extreme, and are similar to those which occur after the sudden development of pneumo-thorax; but the general resonance on percussion immediately excludes this latter affection.

In acute rheumatism a sudden elevation of temperature may occur, which should always suggest the development of pericarditis, but may be the precursor of cerebral rheumatism. In a carefully studied case observed by Wood,[7] the temperature rose suddenly, in the course of an attack of rheumatic fever, to 108⅘° F. Delirium followed by stupor succeeded the elevation of temperature, rendering the case an example of cerebral rheumatism, although pericarditis also existed. The symptoms of gastric inflammation may also mask the latent development of acute pericarditis. Cerebral symptoms may occur in the course of the eruptive fevers, in Bright's disease, or in acute tuberculosis, exhibiting the implication of the nervous system by these processes; but cerebral symptoms occasionally precede the development of pericarditis in any etiological relation, and the præcordia should, therefore, always be carefully examined.

In children, persistent wakefulness, screaming, or restlessness may follow measles or scarlet fever, and if an examination be instituted the physical signs may disclose the pericardium to be the true seat of disease. These cerebral symptoms may be accompanied by moderate delirium, which may be a protracted disorder lasting two or three weeks, or even months, finally ending in insanity. The manifold disturbances originating in the cerebro-spinal axis may be seen in cases of pericarditis, whether produced as a consequence of rheumatism or albuminuria, or from other causes.

Pericarditis with effusion may be mistaken for a tumor of the anterior mediastinum. The diagnosis of pericarditis must be sustained by evidence showing the dependence of this process upon rheumatism, syphilis, nephritis, or propagated inflammation.

The distention of the pericardial sac due to pericarditis exhibits a definite outline. The dulness of a tumor is irregular, with a tier of dulness upon a higher level than in effusion. The pressure symptoms incident to mediastinal disease are less marked in pericarditis, and in mediastinal disease disturbance of the heart's rhythm is less frequent. Kussmaul states that there are two signs characteristic of chronic pericardial disease, or inflammation with thickening and adhesion, viz., a complete, or almost complete, failure of the radial pulse during inspiration, and simultaneously visible swelling of the great veins of the neck, instead of the collapse that usually takes place during this portion of the respiratory act. Adhesion of the great vessels to the sternum, either directly or through the medium of the pericardium, is supposed to account for these phenomena. Febrile movement is usually present in pericarditis, and, while a possible temporary feature, is not persistent in the case of new growths, unless they are complicated by inflammation in the pulmonary tissues. Finally, the progress of the case in mediastinal tumors will usually produce cachexia. Enlarged glands in the neck, or secondary growths, will decide the question.

The differential diagnosis possesses more than a theoretical interest when we remember some of the statistics of mediastinal growths.[8] At Kronstadt, in the Marine Hospital, out of 158 post-mortems of cases of malignant mediastinal disease, 127 were carcinomatous, 31 sarcomatous. Of the former, 81 occurred in men of the average age of fifty-three, and 46 in women of the average age of fifty-six—carcinomata, therefore, occurring most frequently in the middle periods of life. In the 31 cases of sarcoma, 20 occurred in men of the average age of thirty-eight, 11 in women of the average age of forty-eight. Powell gives 24.8 as the mean age for the occurrence of mediastinal growths in general, and it is also a fact that sarcomata occurring in the mediastina are usually situated in the anterior mediastinum. In these cases, until the very last, the appearance of fair health and the absence of cachexia make the differential diagnosis especially interesting. Symptoms of laryngeal pressure, so common in mediastinal tumors, do not occur in pericarditis. In this connection it is interesting to note that Kolaczek[9] reports a case of resection of the third to the sixth left rib, with a portion of the sternum, for the removal of an echondroma which was situated in front of the pericardium. The differential diagnosis of pericarditis from inflammation of the anterior mediastinum may occasion difficulty. The latter is, however, an infrequent process; its etiological relations are traumatic, or mediastinal abscess occurs in connection with caries or fracture, or after an operation in the neighborhood of the throat or neck, or of suppurative disease elsewhere in the thorax, as abscess of the lung or empyema. The pain in cases of abscess is deep-seated, constant, and slowly increasing, thereby differing from the pain of pericardial inflammation. There may also be a hectic type of temperature, with sweating. In mediastinal abscess there will also probably be a tendency to point, with the appearance of a fluctuating, circumscribed, superficial tumor at the sternal border or adjacent to this bone. There may also be tenderness on pressure, associated with pain, and an œdematous condition of the tissues of that portion of the sternal region covering the tumor. Pulsation may accompany abscess, but will be of a transmitted variety.

There are no conclusive symptoms which indicate the purulent character of a pericardial effusion, and the diagnosis of the condition depends upon the same evidence that must be accepted in purulent pleural effusions. Passive pericardial effusion may be suspected in cases of general anasarca complicating morbid processes attended with venous repletion.

Prognosis.—The prognosis in acute pericarditis depends first upon its etiology, second upon the character and the amount of the effusion, and also, to some extent, on the age and state of health of the patient. Pericarditis dependent upon rheumatism is rarely fatal—is never so, according to Bamberger. Walsh observes that in only seven or eight instances in his experience did death occur from rheumatic pericarditis in a previously healthy person. In eighty-four cases reported by Latham, McLeod, and Bouillaud, there were but eight deaths, and in some of these fatal cases endocarditis existed. In rheumatic pericarditis a very high temperature, especially if the rise is sudden, is a grave symptom. It may presage intracranial complication, but is in itself alarming. In pericarditis complicating exanthemata, recovery is the rule,

or, when death occurs, the result is attributable rather to blood-poisoning or pulmonary complications. The pericarditis of pyæmia or of scurvy is, as a rule, a very serious malady, and the same may be said of the pericarditis of Bright's disease, chiefly because the inflammation of the serous membranes in this disease indicates a condition of the blood surcharged with partly reduced albuminoids, and therefore impending uræmia. The prognosis in traumatic cases depends on the character of the injury, for pericarditis, like any other acute inflammation of a serous membrane, may be expected to run a favorable course. The amount and character of the effusion, and the existing complications must be considered in forming a prognosis. A very large effusion may exist, and yet absorption commence and rapidly continue; but fatal syncope has followed sudden exertion in cases of large effusion. The pericardium may safely contain a pint of fluid, if it is effused slowly. A large effusion is serious chiefly when the pericarditis is complicated by a heart already weakened by endocardial disease or fatty degeneration. The most serious symptoms are great dyspnœa, feeble action of the heart, small and irregular pulse, lividity, and delirium, or other nervous symptoms. Walsh observes that the whole class of reflex phenomena are of excessively bad augury, and when highly marked choreic symptoms have occurred in childhood he never knew recovery to ensue; and he adds that dysphagia, at any age, is of very fatal significance. Purulent or hæmorrhagic effusions are naturally more serious, though not necessarily so; instances of recovery after operative treatment are on record. The complications of pericarditis markedly influence the prognosis; pleurisy or pneumonia may exist, yet the mere fact that rheumatism is associated with pericarditis does not greatly enhance the gravity of the prognosis. Anti-rheumatic treatment may cut short the pulmonary processes, as well as abort the rheumatic attack, and when these affections exist as complications of pericarditis, especially in pneumonia, the prognosis chiefly centres upon the question of amount of lung implicated. Double pleuro-pneumonia is possible as a complication of rheumatic pericarditis, and the prognosis is subject to the same rule. Danger to life must be also calculated by the age and state of the vital powers of the patient. The very young and very aged are unpromising subjects. Sibson has shown that while females are more liable to acute articular rheumatism than males, males are more often attacked with rheumatic pericarditis; also, that endocarditis accompanies pericarditis more frequently in males than in females, and that after the twenty-fifth year males are subject to pericarditis three times as often as females. The remote prognosis is dependent upon the anatomical conditions. More or less adhesion of the pericardial surfaces ensues even in favorable cases, and complete obliteration of the pericardial sac has been known to occur. In 70 cases of pericardial adhesions analyzed by Louis, they were general in 60, partial in 10; and in 86 cases of old adhesions analyzed by Chambers, 51 were universal, 4 nearly so, 29 partial. If mere adhesions, or even agglutination, exist, the health does not necessarily suffer; hypertrophy, atrophy, or degeneration of the heart may be followed by the effects incident to defective propelling power in the heart. When valvular lesions coexist pericardial adhesions render them more intractable to treatment. Passive congestion of the lungs or œdema may ensue. Cardiac dilatation may occur as the result of the weakening of the heart from myocarditis. Fibroid degeneration of the heart is sometimes associated with pericarditis, especially if the process be secondary to syphilis. Fatty degeneration of the heart may follow extensive pericardial adhesions forming at the base of the heart, which by their contraction and pressure interfere with the current of the blood through the coronary arteries. These conditions naturally have a decided influence on the prognosis when the diagnosis can be made. The duration of simple pericarditis may be regarded as from one to three weeks. If it do not prove fatal in this period the disease ends in recovery or passes into the chronic form. Andral reports a case which ended fatally in twenty-seven hours, and sudden effusion may induce death in a few hours by causing mechanical paralysis of the heart.

Treatment.—Pericarditis may be considered a benign affection if it is not improperly or unduly treated. In articular rheumatism salicin and the salicylates have a well-deserved reputation, and are commonly employed with success in the treatment. They affect the process chiefly by moderating pain and fever, and sometimes shorten the attack. Probably the latter effect can be secured in those cases in which the natural emunctories—skin, kidneys, and intestinal tract—can thoroughly eliminate the morbid elements from the blood. In graver cases the use of the alkaline treatment is also necessary, perhaps because the acid urates require an alkaline base before they can be eliminated freely. Neither the first-named compounds nor the alkalies are of much value in preventing the occurrence of rheumatic pericarditis, but their use is not contra-indicated by the complication of pericarditis. At the same time it must be remembered that the pulse of pericarditis may indicate an irregular or feeble action of the heart at the onset of the attack, and since salicylates are known to depress the action of the heart, in such cases they should be given in combination with ammonia. Sixty grains of salicylic acid form, with fifty grains of carbonate of ammonia, a double decomposition, and, when administered in syrup and water, offer a useful and palatable mode of prescribing the remedy. Salicylate of cinchonoidine is a very efficacious preparation. A little brandy or whiskey may be given for the first twenty-four hours, after which the action of the heart usually becomes regular. Whiskey can probably be given freely with less danger of disturbing the secretions than brandy, and carbonate of ammonia in emulsion may be required if symptoms of cardiac failure are formidable.

Salicin or the salicylates are indicated in pericarditis to lessen pain and fever, though they do not always influence the progress of the inflammation. The alkalies, which are commonly administered in acute pleurisy, have a favorable effect in this process, as in other inflammations of the serous membranes. If the rheumatic process does not yield somewhat to the salicylates in three to five days, or if the effusion or weakness of the heart, or the pressure of complications, such as pneumonia or pleurisy, render the use of the salicylates improper, large doses of the acetate of potassium are very serviceable. Half an ounce in the twenty-four hours, in broken doses, will be useful not only to combat the rheumatic poison, but also as a diuretic.

When the effusion is large, the use of cardiac stimulants may be the only necessary treatment. Tincture of digitalis with carbonate of ammonia, or alcoholic stimulants, may be indicated to support the action of the heart, and as the rapid effect of stimulants is required, the free use of ammonia and alcohol will often produce superior clinical results compared with the slower operation of digitalis.

Rest is an important part of the management of pericarditis; from the outset the greatest care should be taken to secure bodily and mental quiet. If the effusion is large, the patient should not be allowed to rise from bed even to evacuate the bowels, or for any other purpose, and the warmth and quiet of the bed tend to secure the best results in the rheumatic complication. Opium or morphine in moderate doses is often necessary to allay pain and quell the excitement of the nervous system, which are often conspicuous in the young. To avoid the effect on the secretions, opium or morphine may be given with ipecac, in the form of Dover's powder, or with belladonna. Restlessness at night, or outbreaks of excitement, are particularly favorably influenced by opium. Chloral has been advocated by some to secure rest without affecting the secretions, but its depressant action on the heart renders the drug objectionable.

The local treatment of the effusion by blisters and iodine rests upon the same basis as does the employment of these remedies in the case of pleurisy. In the acute stage blisters may tend to accelerate the action of the heart if applied over the præcordia. Local blood-letting by cups

and leeches was formerly much employed. The disease, however, occurs more frequently among the young, or among those not strong and vigorous, than in healthy persons in the prime of life. These active measures have, therefore, been abandoned. Poultices of flax seed or hops may be applied over the præcordia, or cotton may be substituted for the poultices; hot stupes or fomentations may also be used. The application of cold to the cardiac region, either in the shape of cold compresses frequently changed, or of a bladder of ice, has been practised by French and German physicians. Gendrin's method consists in keeping a bladder of ice over the heart for from one to three hours, until the pulse and temperature have come down to about the normal condition. Mercurials have been abandoned in the treatment designed to lessen the effusion, and the same may be said of hydragogue cathartics or diuretics.

It is surprising how suddenly and rapidly a very large effusion will be reabsorbed if rest and quiet, with supporting food and stimulants, form the sole plan of treatment. The diet should be of the most easily digested and nourishing kind. Milk, eggs, and animal broths should be given in small amounts, and as frequently as the strength of the patient demands food. In lingering effusions the use of potassium iodide internally, or the painting of the præcordia with iodine, may be appropriate.

During convalescence care should be taken to keep the patient quiet, since the walls of the heart are apt to be in a weakened condition, and should not be overtaxed for two or three months. Children should not be permitted to play violently during this time.

If the pericarditis complicates any form of Bright's disease, those means should be employed which will favor the elimination of the urea—in a word, the treatment of uræmia. Local treatment is not necessary in these cases, and opium should be avoided.

If pericarditis occurs in connection with septic or pyæmic processes, supporting measures are demanded, and the same is true of cases of pericarditis which complicate acute diseases, if there is marked depression. In pericarditis, when secondary to adjacent inflammatory processes, the treatment must be combined with that adapted to the primary condition.

It is a remarkable fact that patients rarely die from the pressure upon the heart produced by the pericardial effusion; that is to say, the urgent symptoms connected with the effusion are of short duration. In acute serofibrinous exudation aspiration should not be thought of unless the evidences of heart failure and venous repletion of the lungs are extreme. In fact, the pericardial effusions should be managed exactly as pleural effusions, by internal remedies, by tapping, injection, or drainage, according to the amount and character of the effusion, and the stage of the disease. In a monograph by Roberts, an account of sixty cases is given, with twenty-five recoveries, or forty per cent. He states that the best points to tap are in the fossa, between the ensiform and costal cartilages on the left side, and in the fifth left interspace, near the junction of the sixth rib with its cartilage, or from two to two and one-fourth inches to the left of the median line of the sternum. The latter he considers the point of election. Aside from the avoidance of injury to the heart or the pleura, the selection of this point enables the operator to avoid wounding the internal mammary artery. This artery runs parallel with the edge of the sternum until it reaches the lower edge of the sixth costal cartilage; here, or in this neighborhood, it bifurcates into the superior epigastric, continuing directly downward and outward in the sixth interspace. The trunk in this region is somewhat less than three millimetres in diameter, and its two branches from one and a half to two millimetres. Cruveilhier and Sappey give as the average distance from the sternum four or five millimetres. Some measurements of Roberts show it to be one-fourth to one-half an inch, which would correspond to from six to twelve millimetres from the left border of the sternum.

Many instruments have been suggested as suitable for paracentesis of the pericardial sac. Pepper has designed one of the best; it is a double cannula, the inner tube of which is furnished with a fine needle-point. After introduction the inner tube, with the needle, can be withdrawn into the cannula until its point is sheathed. The cannula can be attached to the tubing of an ordinary aspirating apparatus. In Huidenlang's[10] case one thousand cubic centimetres were withdrawn by two tappings, and recovery followed. The removal of a small amount of serum, in Pepper's[11] case, in which only eight ounces were removed, afforded great relief to the distressing symptoms, and rapid reabsorption followed the operation, the patient being able to get out of bed twenty-six days after.

The progress of modern surgery seems to demand that purulent accumulations in the pericardium, when recognized, should be treated by incision and drainage, similarly with purulent pleural effusions. Aspiration, or the use of a fine trocar and cannula, was first recommended by Bamberger and Friedreich, with subsequent injection of chlorine water or iodine, or irrigation by other antiseptic solutions. Fothergill regarded the procedure as a forlorn hope, but thought it capable of yielding relief. The practice approved by Roberts is that of removal of the purulent collection with the aspirator.

Bristowe gives the details of the operation: The most eligible spot for puncture he considers to be one toward the inner extremity of the fourth or fifth interspace, close to the sternum, and suggests that the tissues be divided with the scalpel, one by one, until the parietal layer of the pericardium is reached, and then that a puncture be made carefully with a fine trocar and cannula. The preliminary use of a fine aspirating needle for diagnostic purposes is suggested. The spot already recommended for puncture in sero-fibrinous effusions would seem most eligible. Flint, Sr., has observed that in suppurative pericarditis aspiration is always indicated; but he also states that if, after repeated aspirations, pus continues to reaccumulate, a permanent opening into the pericardial cavity, with injections, affords the only hope of effecting a cure. Recently West[12] has reported two cases. One was of idiopathic purulent pericarditis, in which incision was followed by complete recovery. In the second case, which was one of multiple abscess following a fall, incision of the pericardial sac was practised, and twenty-four ounces of pus evacuated. Death occurred nine weeks after the fall, but the cavity of the pericardium had been nearly obliterated in the short space of two weeks, and West has expressed the opinion that opening the pericardium is not a more hazardous proceeding than opening the pleura or the peritoneal cavity. The most interesting recent case is reported by E. A. Michaeloff.[13] A woman, aged thirty-five, entered the hospital with symptoms of suppurative pericarditis. The liver was enlarged, there were anasarca, albumen in the urine, and general emaciation. Increasing dyspnœa, cyanosis, and weak pulse, together with complete inability to sleep, made puncture of the pericardium necessary. The operation was accordingly done, the needle being introduced at the fourth intercostal space. Puncture resulted in the escape of nearly three ounces of pus, followed by half the quantity of almost pure blood. Inasmuch as improvement continued for only a short time, on the second day an incision was made, four-fifths of an inch in length, close to the sternum and in the region above indicated. After removal of about a quart (two pounds) of blood-colored, bad-smelling pus, the pericardial sac was washed out with a solution of resorcin, and drainage established. Immediately after the operation good effects were manifested, the dyspnœa disappearing, and the frequency of the pulse diminishing from 120 to 90. Improvement was, however, only temporary, and the patient died in eighteen hours, in collapse. Post-mortem examination revealed the presence of fatty degeneration of the heart, with dilatation, marked right hydro-thorax chronic perimetritis, and a general marasmic condition.

Gussenbauer[14] has successfully treated purulent pericarditis following acute osteo-myelitis at the shoulder, by resection of five ribs and washing out the sac with a thymol solution.

The treatment of chronic pericarditis with pericardial adhesions must embrace the management appropriate to the lesions of the cardiac muscle which have been engendered. Rest, careful diet, and suitable cardiac support by digitalis, are the chief methods required.

In chronic disease of the heart one must avoid the tendency to look to the heart for an explanation of all the complaints of the patient. Persistent and careful attention to the general health will often accomplish the best results in these cases. *Edward Tunis Bruen.*

[1] Charlestown Med. J. and Rev., 1858. [2] Diseases of the Heart.
[3] Fagge: Path. Soc. of London, Trans., vol. xxv., p. 95.
[4] Fagge, loc. cit., p. 95.
[5] Constantin Paul: Maladies du Cœur. Paris, 1883.
[6] Virchow's Arch., Bd. xciii., Heft 3.
[7] Phila. Med. Times, May 30, 1874.
[8] Virchow's Archiv, Bd. xciii., Heft 3.
[9] Deutsche Archiv für Klinishe Med., 1882., Ed. xxx.
[10] Archiv für Klin. Med., xxiv., p. 452.
[11] Med. News and Library, March, 1878.
[12] Medical Times and Gazette, December 8, 1883.
[13] Meditsinskoye Obozrenye, 1885, No. 5; also, Centralb. für Chirurgie, July 4, 1885.
[14] Wiener Med. Wochenschr., November 21, 1884; also, Med. News, Philadelphia, January 15, 1885.

PERINEORRHAPHY, PRIMARY, OR PERINEOPLASTY. By primary perineorrhaphy is understood an operation for the restoration of a lacerated perineum immediately after the completion of the third stage of labor. It is only within the last decade or so that the necessity for primary closure of perineal wounds has been acknowledged. And the recognition of its importance by the profession generally has been due to the teaching of surgeons on the broad basis "that all freshly made wounds should be closed at once."

The object of this article, however, is to point out certain indications for the operation, and the best way to perform it.

Indications for Operation.—Very slight tears of the fourchette occur in almost every first labor, and it is not thought necessary to interfere in such cases. But should the vagina and perineum be involved to ever so slight an extent, it is better to close the wound at once. It has been stated by some authors that perineal lacerations will heal by first intention without the aid of sutures, but if such an occurrence ever does take place, it is so rare that it is not worthy of any material recognition. Of six hundred cases of laceration observed by Reamy ("Gynec. Trans.," 1887, 576), of the first and second degree, not one had healed by primary union. It is therefore generally acknowledged that in *no* case does primary union take place without surgical closure. It is also acknowledged that when a laceration heals by granulation, it involves the formation of cicatricial tissue and other deformity.

Limit of Time wherein Primary Union may be Obtained.—The best time to operate is directly after the expulsion of the placenta; but if anything should interfere to prevent the performance of the operation at this time, such as want of necessary instruments, etc., it will be quite safe to operate within the following twenty-four or thirty-six hours, to obtain good primary union. The writer has operated successfully, upon two occasions, at twenty-four and thirty-six hours, respectively, after completion of labor.

Methods of Operating.—The methods of performing the primary have been practically the same as those adopted in the secondary operation, with one exception, which will be spoken of more in detail further on.

Goodell says: "Immediately after the delivery of the placenta, pass deeply two, three, or more wire sutures, securing each one by merely twisting its ends together. Each suture is entered about an inch from the cutaneous margin of the wound, and each one, excepting the lowest, is made to emerge on the mucous membrane of the vagina, very near to the raw surface. The lowest stitch should always be entered a little below the lower angle, or fork, of the wound, and lie buried in the recto-vaginal septum. The sutures are passed in pretty much the same manner in both primary and secondary operations. Let me, however, add that you may merely twist the ends of the wire together in the primary operation, and not clamp them, because the parts are now relaxed, and there will not be much tension on the stitches."

Dr. Carstens, of Detroit, passes the sutures in the same way as above described, but adds quite a number of perforated shots to each wire, so that he can tighten the sutures as the swelling goes down. This is contrary to Dr. Goodell's experience, and the writer has always met with the reverse difficulty, viz., of judging the exact amount of tension necessary to prevent cutting into the tissues from *excess* of tension.

There have been other methods of performing the primary operation published, but they differ chiefly in the material used for sutures. Dr. James B. Hunter, of New York, passes two or more deep *intra-vaginal* catgut sutures. In this way the pain accompanying skin sutures is avoided, and Dr. Hunter tells the writer he has obtained good results by this method. Another method, chiefly carried out in Germany, consists in passing a continuous catgut suture from the beginning of the tear, high up in the vagina, down to the posterior commissure, and still continued downward, uniting the integumentary part of the lacerated perineum.

The use of the serre-fine to close a perineal laceration has been condemned, and it is thought justly so. Dr. Paul F. Mundé, of New York, thus describes his method of performing the primary operation for ruptured perineum: "With my left index-finger in the rectum as a guide, I insert the point of the large needle, which is firmly grasped in the needle-holder, about one-fourth of an inch to the right of the bottom of the rent, and with a quick sweep carry it completely under the rent, emerging at a corresponding spot on the left side; the second needle is passed in precisely the same way, and so on, until the fourchette is reached, where the uppermost suture must lie. Particular care must be taken to have all the sutures outside and under any rents which there may be in the vaginal wall, and not to allow the suture to escape from the tissues during any part of its course. Having inserted all the sutures the wound is thoroughly cleansed, and, beginning with the first, the stitches are tied with the knot slightly to the side of the rent, until the uppermost is reached, when the sponge is removed and the last stitch rapidly tied." In complete laceration Dr. Mundé says: "I should first unite the rent in the septum, knotting the stitches in the rectum and cutting them short, and then proceed as in partial laceration. The rectal stitches can be allowed to cut out, or catgut can be used." Dr. Mundé uses silk for suture, and a long straight or curved needle (two and one-half inches). He recommends daily vaginal antiseptic douches until the stitches are removed.

Single Suture Method.—The writer will now describe the method devised by him some time ago (*Am. Jour. Obst.*, 1884, 16), which has been endorsed by most of the recent authors writing on gynecology in America and Europe, and is being almost universally practised at present with satisfaction. The writer became convinced that *one* purse-string suture, if placed correctly, would do all that *many* sutures could do toward obtaining union of the parts. He arrived at such a conclusion for the following reasons: The vaginal walls, when relieved of the distending element, collapse, so to speak. The edges of the tear fall together in close contact, and, there being so much of tube-calibre to spare between its fully distended condition and that of complete involution, there will really be no side-traction brought to bear upon the edges of the wound for a week or ten days after delivery, and by this time strong union will have taken place. Furthermore, a recently lacerated perineum, accompanied, as it is in some instances, with laceration of the posterior wall of the vagina to varying degrees, is an open wound with a sliding base (recto-vaginal cellular tissue), and, consequently has no fixed point from which union could begin, or where the edges could be maintained in apposition. As a corollary to these truths it became evident that one suture would prove sufficient, for the following reasons: It would give a fixed point from which union could begin; it would be sufficient to sup-

pert the edges of the wound in apposition during the period of rest required at the puerperium; and, by the time involution and side-traction had set in, union would have become sufficiently strong to resist such influence; also, there could occur no pus-pockets between the sutures and free drainage both above and below the sutures would be maintained. The wound, also, would be completely shut off from the vagina and therefore from the discharge, for the conveyance of which the vagina acts as a drainage tube.

If the efficiency of the "*single-suture*" method could be proven its simplicity and ease of application would cause it to supplant all other methods in practice. The writer has applied this method during the last four years in every case of necessity, many being done in consultation for other physicians, and he has not experienced a single failure on the part of the laceration to unite firmly before the suture was removed on the eighth day. The material which was used in the majority of cases was No. 13 Snowdon's iron-dyed silk, but lately silkworm gut (salmon size) has been employed, and it has given much cleaner suture tracks than the silk. The writer, therefore, recommends this suture material in preference to all others. The gut will hold best when tied in a double-hitch knot, and this is more satisfactory than fixing with perforated shot.

The instruments required consist of a straight Emmet needle three inches in length, and a strong needle-holder;

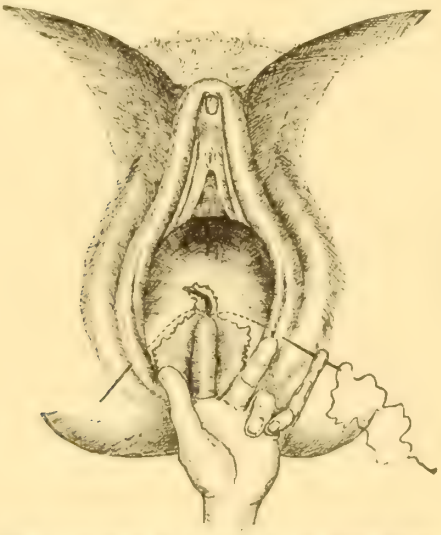

FIG. 2810.—Method of Introducing "the Single Suture."

the Russian pattern is preferable. The needle should be made of the very finest steel, otherwise it is liable to snap, from the strain put upon it, just at the most critical moment, and thus cause much annoyance to the operator. Messrs. Codman & Shurtleff, of Boston, have the proper needles for this operation in stock, but any instrument-maker can make them. Curved needles cannot be used to the same advantage as straight ones, on account of the difficulty of passing them under circumrectal tears.

After the expulsion of the placenta, the attendant having assured himself that there are no portions of membranes left behind, the parts are examined, and if a tear is discovered the patient is moved gently across the bed, her hips being placed on the edge in the dorsal or dorso-gluteal position. The uterus is now firmly compressed and all clots squeezed out; the maintenance of compression is entrusted to a female assistant. A small piece of waterproof is slipped under the buttocks of the patient and allowed to fall over the edge of the bed, leading into a basin on the floor. From a fountain irrigator, hung on a nail in the wall, containing a gallon of very hot (1:5) solution of corrosive sublimate, a steady stream is allowed to play upon the wound, the edges of which should be well separated by the fingers of the left hand. This stream should be continued until the hæmorrhage from torn vessels ceases, when the wound can be examined regarding its height, depth, and irregularity of contour. The forefinger of the left hand, anointed with vaseline, is now passed into the rectum and the rectal wall is drawn

FIG. 2811.—"Single Suture," Tied.

forward into the lumen of the vulva, until the upper angle of the tear is under the pubic arch (Fig. 2810). This procedure is very essential toward success in passing the needle, and if the introduction of two fingers into the rectum would seem to give more power over the parts, they should be used.

At this stage, if there should be any trickling of blood from the uterus over the wound, a large piece of clean absorbent cotton should be passed high up into the va-

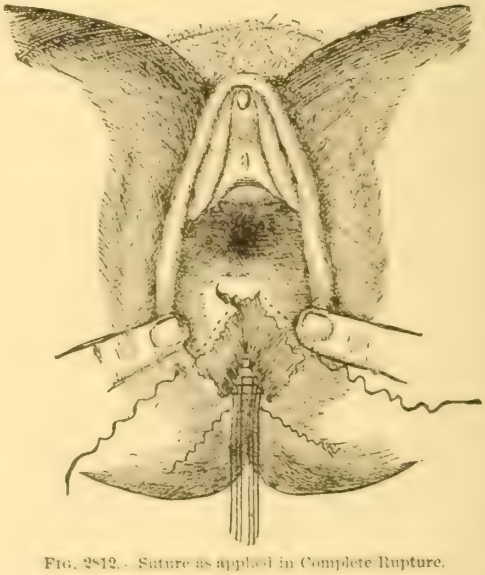

FIG. 2812.—Suture as applied in Complete Rupture.

gina above the wound. A sponge is not recommended, as it often distorts the shape of the passage, and causes confusion when the endeavor is made to pass the needle correctly. The operator now takes in his right hand his needle-holder, armed with the needle and a strand of silkworm gut, and placing himself between his patient's knees, throws his whole weight against her left knee,

thus thoroughly controlling that leg with his right shoulder and arm. His right elbow is thrown somewhat backward, and as close as possible to his body; his right wrist is strongly supinated and abducted. The needle is passed into the tissues at the beginning of the tear on the left side,* at about half an inch from the margin, directly upward in the direction of the long axis of the vagina, and close to the edge of the tear all the way. As soon as the point arrives at the upper angle of the tear, this part is thrown more forcibly forward through the vulva by the fingers in the rectum, and at the same time the right wrist of the operator is sharply adducted and flexed, throwing the point of the needle across the apex of the tear and downward *under* the circumrectal part of the wound. The elbow now leaves the side of the operator's body, and the needle is forced downward and outward under the mucous membrane of the right side of the wound, until its point strikes the beginning of the tear on that side, corresponding to a similar point of entrance on the left side; the needle and suture are now drawn through (Fig. 2810). During the passage of the needle as described, the operator should be constantly on the alert, with his fingers in the rectum, that the needle does not take up a bit of that tube in its passage; and with the thumb of the same hand in the vagina, that the needle does not appear on that side of the wound. The suture before being tied should be carefully examined to determine that it is *completely* buried in the septum, and can neither be seen nor felt in any part of its course. If it is, it should be withdrawn and reinserted. The cotton tampon should now be removed, the wound carefully irrigated, and the suture tied in a double-hitch knot with sufficient tension to bring the edges of the wound firmly together, and to completely shut it off from the vagina by bringing the apex of the tear in close and firm contact with the torn edges of the posterior commissure (Fig. 2811). In this way we restore the posterior vaginal wall and the reflections of the pelvic fascia. The ends of the suture are cut short, the external parts carefully sponged, and the vulva dressed with sublimated jute. The patient is then gently placed properly in the bed, and the bandage is applied.

Fig. 2813.—Perineum Lacerated, and before Introduction of "Single Suture." (This and the following two cuts represent diagrammatic sagittal-mesial sections of the uterus and lacerated perineum.)

Fig. 2814.—Suture Introduced and Drawn Half-way.

It is advisable to use a $\frac{1}{4000}$ solution of corrosive sublimate as an irrigation once every morning or every second morning, according to the amount of discharge, fetor, etc., until the suture is removed on the eighth day. Should the case be one in which the tissues are so badly torn as to lay bare the sphincter ani, the operation, as above described, will be sufficient. But the writer has seen cases in which the sphincter was stretched to its utmost and suddenly snapped, allowing the child to pass through without rupture of the recto-vaginal septum in any part. In such a case the writer advises the insertion of Emmet's "sphincter-stitch" to control and bring together the torn ends of that muscle, in addition to the *single suture* as described.

Fig. 2815.—Suture Tied and Wound completely Closed.

In a case in which the laceration has been complete, involving the recto-vaginal septum, this latter must be repaired first by interrupted sutures, which should be tied in the rectum, cut short, and allowed to work their way out. This procedure, combined with the use of the *single suture* at the beginning of the tear, will be found all that is necessary even in such a case. Here the last rectal stitch can be inserted in such a way as to control the torn ends of the sphincter (Fig. 2812).

T. Johnson Alloway.

PERINEPHRITIS. Definition.—Inflammation of the perirenal connective and adipose tissue.

Etiology.—Perinephritis may be either primary or secondary.

Primary perinephritis, which is rare in comparison with secondary perinephritis, may be caused by wounds and contusions of the kidney or of the perinephritic tissues. It infrequently occurs spontaneously in various infectious diseases, as typhus fever, variola, and pyæmia. It is sometimes, with questionable propriety, ascribed to the effects of cold and over-exertion. In some cases no adequate cause can be discovered. Men are more often attacked by perinephritis than women.

Secondary perinephritis, which is much more frequent than the primary form of the disease, is caused by the extension of inflammation from neighboring tissues or viscera. The organ whence the inflammation generally proceeds is the kidney, when the latter is the seat of calculous pyelitis, pyelo-nephritis or pyo-nephrosis, of neoplasms, cystic degeneration, or tuberculous inflammation. Perinephritis may also be secondary to any retro-peritoneal suppuration, as perityphlitis, typhlitis, and vertebral caries, or, more rarely, to intra-pelvic suppurations.

Morbid Anatomy.—Perinephritis may be either chronic or acute. In the former variety, which has no practical importance, the product of the inflammation is new-formed perirenal connective tissue. Acute perinephritis is attended by the same morbid anatomical changes which accompany inflammations of connective tissue in general, and may end in resolution, which is rare; in gangrene, which is rarer; or in abscess, which is the most frequent termination. In cases of primary perinephritis and of perinephritis secondary to kidney diseases, the abscess originally forms in the perirenal tissues and may remain localized in this situation. The pus generally, however, escapes from its original cavity and burrows in various directions, seeking to effect an exit upon some cutaneous, mucous, or serous surface. The abscess, when allowed to pursue its natural course, points and opens externally in the lumbar region, in the majority of cases, but it may discharge into various viscera or upon different external and internal surfaces. Thus, the pus may make its appearance in the gluteal region, in one of the abdominal regions, upon the thigh or leg, having passed down the sheath of the psoas muscle, or at the perineum. The abscess may rupture into the colon, the kidney, the peritoneal cavity, the small intestine, the stomach, the bladder, the vagina, the rectum, the pleural cavity, or the lung. The viscera and cavities last mentioned are, naturally, among those least frequently invaded.

Symptomatology.—The symptoms are general and local. The former embrace the febrile phenomena ordinarily accompanying inflammation. When suppuration occurs, the fever assumes the so-called hectic type, characterized by chills, high temperature, and profuse perspirations. The chief local symptom is perinephritic pain, which is constant, deep-seated, and non-lancinating, which may radiate throughout the abdomen, down the thighs, or into the testicles, and which is accompanied by tenderness on pressure. While suppuration is taking place, the pain is often described as throbbing or pulsating. In the event of the opening of the abscess in the lumbar region, a tumor eventually makes its appearance in this situation and the usual phenomena

* When the words "right or left side" are used, they will refer to the patient's side.

of pointing are observed. If the pus burrows in other directions, fluctuation may not be obtained in the lumbar region, in which, however, there may be detected a deep-seated tumor, yielding pus on aspiration. When the abscess is discharged upon other surfaces, or into various viscera, the symptoms differ in accordance with the tissues and organs involved. We may thus have simulated primary psoas, perineal, or pelvic abscesses. If the intestine be perforated, pus appears in the dejecta. If the abscess be evacuated into the renal pelvis, into the ureter, or into the bladder, pus and blood are found in the urine. Peritonitis follows the invasion of the pleural cavity. Vomiting of a bloody and purulent fluid results from perforation of the stomach. Vaginitis, with a similar discharge, follows rupture of the abscess into the female genital canal. If the pus enter the pleural cavity, pyo-thorax is developed, while the expectoration of pus and of blood would bear testimony to the involvement of the bronchi. Pneumonitis, or pulmonary abscess, might then occur as a complication or sequela.

Diagnosis.—The task of the diagnostician is here twofold. He must, first, establish a differential diagnosis between perinephritic abscess and other conditions likely to be mistaken for it, and must then ascertain whether the abscess be primary or secondary.

The other inflammatory conditions most closely resembling perinephritic abscess are pyelitis, pyo-nephrosis, and suppurative nephritis. Pyelitis presents characteristic urinary symptoms (*vide* article Pyelitis, in the Appendix), and is not accompanied by the local signs of perinephritic abscess. Pyo-nephrosis, with obstruction of the ureter, may indeed offer almost insurmountable difficulties to the establishment of an accurate diagnosis. Should the ureter remain patent, or occasionally become so, there would be continuous or intermittent pyuria. In any event, the previous history—possibly embracing, in pyonephrosis, the passage of renal calculi, or, at least, the symptoms of an antecedent pyelitis—will throw light upon the nature of the disease. Suppurative nephritis has symptoms characteristic of itself (*vide* article Kidney, Surgery of the, in this Handbook).

The diagnostician must, in the second place, endeavor to ascertain whether the abscess be primary or secondary. In the former case there will be no symptoms relating to other organs. In the latter case there will be the signs of antecedent renal, pelvic, perityphlitic, retro-peritoneal, or other suppurations.

Treatment.—The diagnosis having been made, therapeutic measures calculated to promote resolution should be first adopted. Those deserving the greatest confidence are, in the writer's opinion, absolute rest either in the prone position or upon the side opposite to the seat of the inflammation; hot applications—preferably hot alcohol and water, in equal proportions—leeches, wet-cups, saline cathartics, occasionally repeated, and a non-stimulating diet. Should symptoms of suppuration be developed in spite of these abortive measures, the tumor must be aspirated, and if pus be obtained, a free incision should at once be made in order to prevent the discharge of the abscess into neighboring viscera or cavities. The after treatment is to be conducted upon strictly antiseptic principles. Should aspiration fail to reveal the presence of pus, the surgeon ought to submit to a consultation the question as to the propriety of undertaking an exploratory operation. If the perinephritis be secondary, measures suitable for the relief of the original disease are urgently indicated. Among such measures may be mentioned the extirpation of a hopelessly diseased kidney, the evacuation of pelvic or iliac abscesses, and the adaptation of necessary orthopedic appliances.

William H. Flint.

PERINEUM, LACERATED. In using the term "Lacerated Perineum" we do so almost entirely with reference to certain lesions of parts of the genital tract occurring during parturition. These parts are, upon rare occasions, lacerated in the non parturient female by such accidents as falling from a height upon hidden or projecting sharp instruments, stakes of wood, and such like. Also women have been gored in these parts by horned animals. It is, however, of lesions of the perineum occurring during parturition that this article will treat.

During the passage of the child through the parturient canal there are two important forces brought into play. First, the retractile force of the upper zones of the uterine muscularis, which, together with the auxiliary aid of the abdominal and thoracic muscles, expels the child. Second, the force of resistance to this driving force of expulsion. This latter force resides principally in the elastic and distensible tissues of the lower genital canal. So long as the normal relations of these forces are preserved all goes well. But if the balance be disturbed in such a way that the force of expulsion overcomes that of resistance in so rapid and marked a degree that essential dilatation of the resisting tissues has not had time to take place, or if the distensible properties of these tissues have been impaired by age or disease, then rupture becomes inevitable. When necessary, these forces can be imitated by art, and if the operator be so skilled as to enable a normal balance to be maintained all goes well, and rupture of the tissues will not be more liable to take place than if nature herself was the artist.

The pelvic floor, through the centre of which the child is evolved, is divided into two segments. The anterior

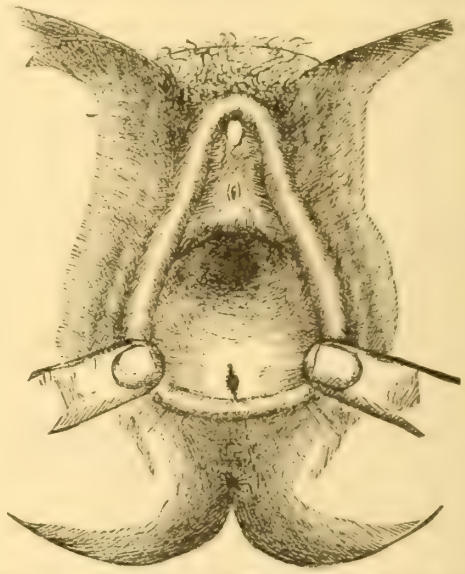

Fig. 2816.—Laceration of Posterior Vaginal Wall, without involving Integument of Perineum.

is composed of the retro-pubic fat, bladder, urethra, and anterior wall of the vagina. The posterior is composed of the posterior wall of the vagina, the rectum, and the perineum, including the muscles to which it gives a fixed point of attachment. During the second stage of labor the anterior segment is drawn upward and the posterior is forced downward, and has to encounter with resistance all the expulsive force of the uterus transmitted through the resilient body of the living child. It can therefore be seen that the posterior segment of the pelvic floor is the part most liable to injury during parturition. And it is injury of the various component parts of this segment to which the term "lacerated perineum" is properly applied.

Varieties.—Now that we know the parts composing the posterior or sacral segment, it will be necessary to formulate a classification of the degrees of laceration according to the parts of this segment involved. No better classification can be given than that of Dr. Gaillard Thomas. It is as follows: (1) Superficial rupture of fourchette and perineum; (2) rupture of the sphincter ani exposing that muscle; (3) rupture through the sphincter ani; (4) rupture through the sphincter ani involving the recto-

vaginal septum. To this list we would add rupture of the posterior vaginal wall and part of the perineum, without involving the skin—a condition which can be detected only by careful exploration of the vagina (Fig. 2816). The writer has seen several such cases, and the recognition of the lesion is important regarding the part it may play in septic infection. This classification has, however, been simplified by designating all tears of the perineum which extend more or less down to the sphincter ani as *incomplete lacerations*, and those which extend through the sphincter and involve more or less of the recto-vaginal septum as *complete lacerations*. In these latter cases the septum may be torn to the extent of from half an inch to one inch, but the tear may run up, during rapid and unskilful delivery with forceps, to the depth of two inches. The writer has seen two such cases. It is stated by some authors that, although the perineum may apparently seem perfect at the termination of labor, yet in a few days a sloughing out of the part may take place as a result of long-continued pressure in delay of the head. This condition must have occurred before the time of the free use of the forceps; the writer has never seen such a result. Among the varieties of laceration it may be mentioned that the head has been forced through

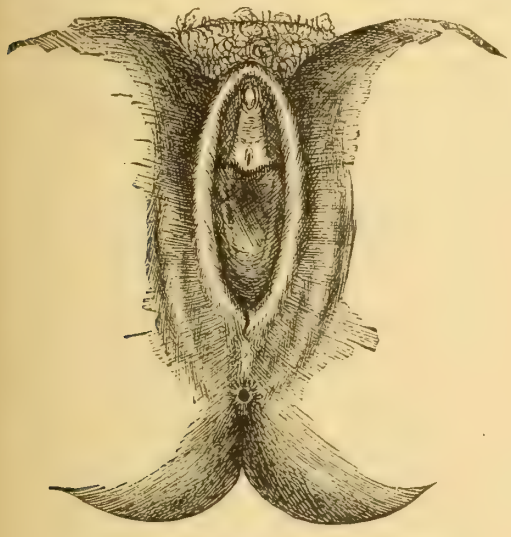

Fig. 2817.—Superficial Laceration of Fourchette.

the perineum (a disproportionately long one) without tearing the fourchette or sphincter ani—the so-called *central laceration* (Fig. 2822).

Etiology.—Among the immediate causes of this lesion are unusual height of the pubic symphysis, narrowing of the pubic arch, lateral deviation of the coccyx, and abnormal concavity of the sacrum. The perineum may be abnormally prolonged in front, so as to shorten the vulvar orifice; or it may be undilatable, as in old primiparæ, or as a result of old cicatrices from previous traumatisms, scrofula, or syphilis.

Unfavorable presentations of the fœtus, and large size and incompressibility of the head, so that moulding is not accomplished, are other active causes. It is also stated that the position of the patient during labor largely influences the fate of the perineum. For example, it is more likely to suffer laceration when the patient is on her back, or in a half-sitting position, than if she is lying on her left side. The truth of this assertion the writer has had ample opportunity of verifying in the large numbers of French-Canadian women attending his clinic, with evidence of extensive laceration having taken place at their first confinement. It is well known that these women are always confined in a half-sitting posture. In this position all the auxiliary forces are brought strongly into play, and the descent of the head through the pelvis is very much more rapidly accomplished than it would be if the patient were lying quietly on her side.

Consequences.—*Immediate*.—Hæmorrhages, septicæmia, delayed involution of the uterus and vaginal walls, pelvic cellulitis, and abscess.

Remote.—Subinvolution of the uterus, retro-displacement of the uterus and ovaries accompanied with descent,

Fig. 2818.—Laceration extending to the Muscle, but not exposing it. (Wound closed.)

of these organs in the pelvis, rectocele, cystocele, cystitis, and ultimately more or less complete procidentia. When the laceration has been complete and the recto-vaginal wall has been involved, retentive power over gases, and in most of the cases also over the fluid contents of the bowel, is abolished. The writer has seen several cases in which both of these unfortunate conditions existed. There is, however, in many cases, a strong cicatricial membrane,

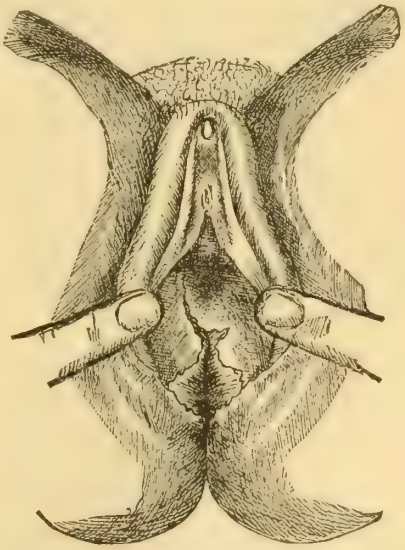

Fig. 2819.—Laceration extending to the Muscle, but not exposing it. (Wound open.)

with a fibrous, cord-like border, which does duty for the sphincter so long as the rectal matter is solid, but has no retentive power over gases or fluids. Consequently these women have to wear a sort of padded truss to support

napkins and supply pressure. There is also a peculiar remote consequence of laceration of the perineum which the writer has seen, but which is not mentioned by any author except Churchill, namely, an annoying mucoid diarrhœa, due probably to the deformity having deprived the rectum of one of its important functions, possibly in

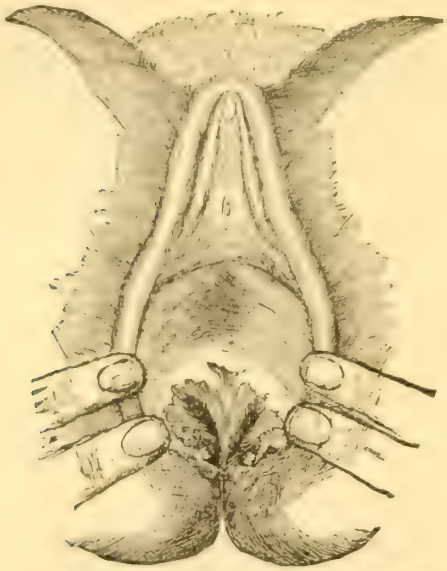

Fig. 2820.—Laceration through the Sphincter, but not into the Rectum.

these cases there may be a slight chronic catarrh of the mucosa as well. This rectal flux tends to debilitate the patient, partly through a process of starvation, and partly through the general effect of the constant drain, and is a strong argument in itself in favor of the operation of perineoplasty. Laceration of any extent invariably begins in the vagina during extrusion of the head, and this laceration is carried downward through the perineal body and

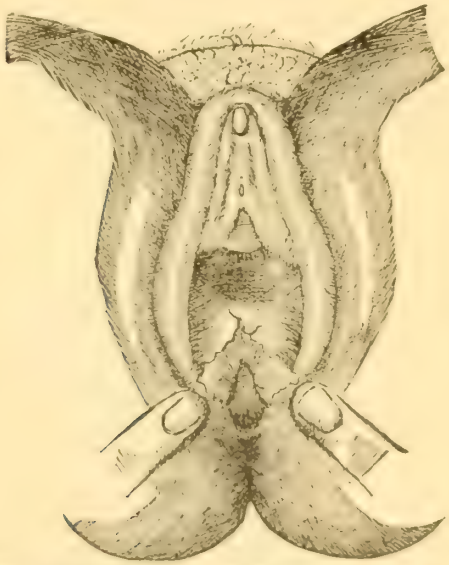

Fig. 2821.—Laceration through the Sphincter, and involving the Recto-Vaginal Wall.

integument. During this stage of labor it will be important to recognize the evidence of a beginning laceration. When the head becomes visible at the vulva during a pain, and recedes again during the intervals, a few drops of blood will be observed to course round the rima vulvæ, and presently to fill it up. Should hæmorrhage come from a higher source, such as the cervix, it will have become apparent long before this stage of the proceedings. But appearing for the first time as described, it will indicate a beginning laceration of the perineum, and preparations may be made for its immediate repair. Lacerations which involve only the fourchette occur in nearly every primipara, and do not call for consideration. These slight skin tears always granulate under careful antiseptic treatment, without leaving any appreciable cicatrix (Fig. 2817). If a laceration extends beyond the fourchette, it may run down *to* the sphincter without exposing that muscle (Figs. 2818 and 2819), or it may strip the tissues and lay that muscle bare to view (Fig. 2823), or it may extend still farther and rend asunder the sphincter in all its fibres without involving the bowel (Fig. 2820). It may go still farther and involve the recto-vaginal septum to any extent as high as the cervical junction (Fig. 2821). A peculiarity of these lacerations is that when the rent extends beyond the so-called perineal body, it does not proceed upward in the median line or posterior column of the vagina, but slips, as it were, to one side, generally to the right, and pursues a lateral, jagged direction alongside the rectum. This fact was observed by Freund some years ago. The fact of its greater frequency on the right side may be due to the corresponding frequency of the left occipito-anterior position, as the face and chin, scraping the right vaginal wall, would impinge with more force on that side. Occasionally the tear will extend upward on both sides of the vagina, unequally. The writer has observed cases in which the depth of the tear had passed deeply round the rectum in the tissue of the ischio-rectal fossa.

Fig. 2822.—Central Laceration.

Preventive Methods.—The various measures recommended for the prevention of laceration of the perineum are numerous and uncertain of success. They all, however, tend to show that the principal endeavor should be to prevent too rapid a delivery of the head, and to relieve, as much as possible, the posterior segment of the pelvic floor from the effects of the full driving force of the uterus during the labor pains. To accomplish these ends the head, when distending the vulva, should be restrained somewhat in its dilating efforts, and drawn up under the pubic arch as much as possible. It is, however, almost impossible to prevent a perineum giving way to a varying degree, when any of the conditions mentioned under the heading of Etiology are present. It should, therefore, be thoroughly explained to the patient and her responsible friends, that the cause or fault of such an accident will be with her, and not the obstetrician. The plan of passing the left arm of the physician between the thighs of the patient while she is lying on her left side, and drawing the advancing head well up against the pubic arch, and at the same time supporting the perineal structure with the right hand, is a good one, and may save some cases from laceration. It should not be forgotten, however, that the support should, under all circumstances, be given to the presenting part of the child and not to the parts of the mother. A most excellent plan consists in passing two fingers of the left hand into the rectum and hooking them under the chin of the child, the thin recto-vaginal wall intervening, and directly after the cessation of a pain, when the soft parts

are lax, causing the head to rotate rapidly under the pubic arch and then slipping the forehead and face safely over the perineum before the next pain sets in. But here again, though we succeed in this little slight-of-hand manœuvre, the after-coming shoulders may produce the most extensive lacerations if their delivery is not managed skilfully.

Ritgen recommends lifting the head upward and forward through the vulva, between the pains, by pressure made with the fingers upon the perineum behind the anus, close to the extremity of the coccyx.

Fastender recommends seizing the occiput with the index and middle fingers of the right hand, and passing the thumb of the same hand well up into the rectum. In this way he strongly controls the head during the pains, and can press it forward and outward at will between the pains.

In practising any of these methods of rectal manipulation, it must not be forgotten or overlooked that there is danger of infecting a freshly made wound in the perineum, when success is not obtained, by bringing the finger or fingers in contact with the wounded parts. We should, therefore, always apply the fingers of the left hand to the rectum, and in this way keep the right hand pure in case it may become necessary to introduce that hand into the upper genital tract after the delivery of the child.

The operation of episiotomy, or that of dividing the lateral borders of the vulva to relieve tension, requires only a passing notice. It is unscientific in its intuition, as it will not save injury to such muscles as the levator ani and deep layers of the pelvic fascia, the rupture of which constitutes the most serious phase of perineal laceration. It has also been known to signally fail in pre-

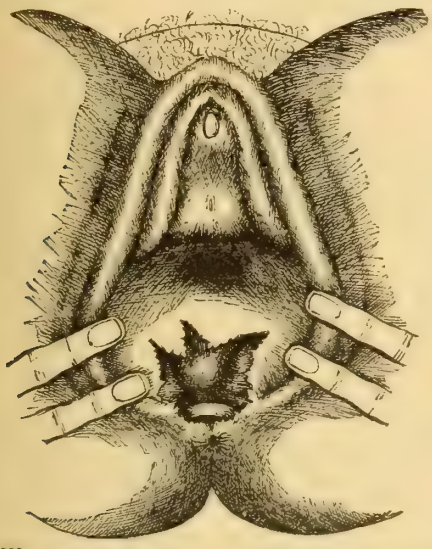

Fig. 2823.—Laceration extending to the Sphincter and exposing it.

venting rupture of the perineum proper, and the operation has now fallen into disuse.

Frequency.—Kleinwächter says the accident occurs in from fifteen to forty per cent. of primiparæ, and from one to ten per cent. of multiparæ.

Treatment. — For treatment, see Perineorrhaphy, Primary. *T. Johnson Alloway.*

PERINEUM, SURGICAL ANATOMY OF THE MALE.

In the skeleton this region corresponds to the outlet of the pelvis. It is a diamond- or lozenge-shaped space bounded in front by the pubis and subpubic ligament, behind by the coccyx, and on each side, from before backward, by the rami of the pubis and ischium, the great tuberosity of the ischium, and the great sacro-sciatic ligament.

The whole space measures about three inches and a half from side to side, and four inches antero-posteriorly. At the posterior part it is from two to three inches deep, anteriorly it only reaches the depth of one inch. The perineal space is separated from the pelvic cavity above by the recto-vesical fascia and levatores ani muscles. A line drawn across from one ischial tuberosity to the other, and passing immediately in front of the anus, would divide the space into two parts (see Fig. 2824), the anterior of which is called the *urethral* triangle or true perineum, and the posterior the *anal* or rectal triangle. The anterior triangle contains the bulb and urethra, with the muscles of the perineum proper; the posterior triangle has in it the rectum and the two ischio-rectal fossæ.

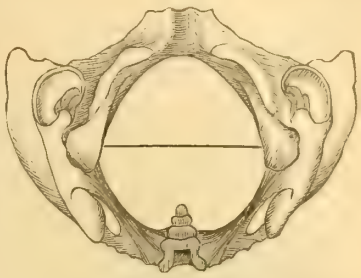

Fig. 2824.—Outlet of the Pelvis. Line dividing outlet into anterior or urethral triangle, and posterior or rectal triangle.

Surface Anatomy.—In the undissected subject the superficial area of the perineum is very limited, especially when the thighs are brought together; it then consists of a narrow space or groove reaching from the coccyx behind to the symphysis pubis in front. In the centre of this groove is an elevation of the skin, called the median raphé, which runs from the front of the anus, over the scrotum, to the under surface of the penis. No vessels cross this line, and in this situation incisions may be made without any fear of hæmorrhage. The osseous boundaries of the perineum may be easily made out through the skin; the great sacro-sciatic ligaments, however, being covered by the gluteal muscles, can only be felt by pressing in a line drawn from the coccyx to the ischial tuberosity. In thin subjects they can be more easily felt. The anus is situated at the midpoint between the tuberosities, and its centre is about one inch and a half from the end of the coccyx. The central point of the perineum is a little more than an inch in front of the anus; this point corresponds to the middle of the free border of the triangular ligament. A knife introduced here, and given a slightly upward direction, would reach the membranous urethra. Immediately in front of the central point may be felt, in all but very fat persons and children, the bulb of the urethra and the corpus spongiosum. Abscesses point, and urethral fistulæ are often seen, in this region.

The membranous portion of the urethra perforates the triangular ligament one inch below the symphasis pubis, and one inch and a half in front of the anus. The skin of the perineum is thin and covered with hairs; about the anus it is of a brownish color and thrown into radiating wrinkles by the contraction of the external sphincter; these folds are much enlarged when the hæmorrhoidal veins are swollen and inflamed. If the skin of the anus be everted, a fine white line is seen which marks the junction of the skin and mucous membrane, and corresponds exactly to the lower margin of the internal sphincter. There are a number of follicles about the margin of the anus, and small subcutaneous abscesses frequently occur in this situation. These must not be confounded with fistulæ. The usual incision in lateral lithotomy passes between the anus and ischial tuberosity, a third nearer the tuberosity than the anus.

If the finger be introduced through the anus into the rectum many important landmarks may be felt. The finger for the first inch is grasped by the sphincter muscles, principally the internal. Here the internal openings of fistulæ may be felt; these openings are rarely much above the upper border of the sphincter ani. One can easily feel ulcers and fissures in this situation, when they are present. In the front wall of the bowel the membranous portion of the urethra can be made out in the middle line, and when a catheter is introduced into the bladder

it can be easily felt as it passes through the membranous portion; with the finger in the rectum a catheter can be guided into the bladder in cases of enlarged prostate, and if the instrument enters a false passage it can be detected and directed into the proper channel. The prostate gland can be felt one inch and a half from the anus, and its condition ascertained if it be enlarged or inflamed. Passing beyond the prostate the finger comes on the trigone of the bladder. When the bladder is distended it may be made out through the rectum as a soft fluctuating tumor. It is more easily felt when the other hand, placed above the pubis, presses the apex downward. The bladder, when distended, may be tapped through the trigone with a curved trocar, without there being any danger of wounding the peritoneum, which generally reaches only to within four inches of the anus. In rare cases the peritoneum passes down between the gut and the trigone. In such cases, of course, in this operation, it would inevitably be wounded.

Fig. 2825.—1, Bladder; 2, prostate; 4, base; 5-6, seminal vesicles and vas deferens; 7, ureter; 8, rectum; 9, sphincter ani. (Roser.

The vesiculæ seminales can be rarely felt, unless affected by disease.

Stone in the bladder in children can be often diagnosed through the rectum. Above the trigone of the bladder transverse folds of mucous membrane in the rectum can be felt; these are soft and velvety when healthy, but when ulcerated or inflamed they feel thick and cause great pain on defecation. Many diseases are diagnosed by the finger in the rectum, viz., ulcers, polypi, hæmorrhoids, stricture of the gut, diseases of the prostate, deep-seated abscess of the ischio-rectal fossa, pelvic tumors, etc.

With the whole hand introduced into the rectum the entire pelvis may be explored, as well as the lower part of the abdomen.

Ischio-rectal Fossa.—The ischio rectal fossa is the space which exists on each side between the rectum and ischial tuberosity. It is of a pyramidal shape, with the apex pointing upward to the pelvic cavity, and is from two to three inches in depth.

Boundaries.—Internally, the levator ani covered by the anal fascia; externally, the obturator internus muscle covered by the parietal layer of pelvic fascia; in front, the triangular ligament and transversus perinei muscle; behind, the lower edge of the gluteus maximus, the great sacro-sciatic ligament, and the coccygeus muscle.

The space is filled with fat, and crossing the fossa obliquely are the inferior hæmorrhoidal vessels and nerves. The anterior portion is crossed by the perineal vessels and nerves, and entering the fossa at its posterior part is the perineal branch of the fourth sacral nerve.

The tuberosities of the ischia have also a cushion of fat over them, and when this is removed several bursæ are seen. The apex of the space corresponds to the division of the pelvic fascia into parietal and visceral layers, or rather to the junction of the anal with the obturator fascia. When the anal fascia is removed the levator ani muscle is exposed, and internal to the levator ani is the visceral layer of pelvic fascia.

The lower end of the rectum is placed between the two fossæ, slung, as it were, by the meeting of the two levatores ani muscles, and held in place by the external sphincter and recto-vesical fascia. The fibres of the levatores ani muscles at the lower end of the rectum are separated from one another, and in this situation the anal fascia is also very thin, so that little resistance is offered to the entrance of pus.

Ischio-rectal Abscess and Fistula in Ano.—Abscess in the ischio rectal fossa is not an uncommon affection, and is often caused by the ulceration of foreign bodies, such as fish-bones through the bowel into the fossa, and there setting up inflammation. Sitting on cold, damp seats after exercise is another, and perhaps the most common, cause of ischio rectal abscess.

When pus forms in the fossa it presents at the points of least resistance, viz., the internal wall of the fossa and the skin at the base. When the abscess breaks through the skin it will be found that after a time a sinus remains, which generally communicates with the bowel; this sinus is called a *fistula in ano*. The internal opening of the fistula is usually within half an inch of the margin of the anus, as at this point pus can more easily penetrate the rectum, because of the thinness of the fascia and the scantiness of the muscular fibres. The external opening may be anywhere in the region of the posterior part of the perineum. To prevent the formation of a fistula, the ischio-rectal abscess should be opened early and freely.

Perineal Fascia.—The superficial fascia of the perineum consists of two layers, between which, in the rectal triangle, is a large amount of fat; in the urethral triangle there is less, and as the fascia reaches the scrotum the fat is replaced by the muscle or dartos tissue of that structure. The deep layer of fascia (fascia of Colles) is limited to the urethral triangle; it is attached to the base of the triangular ligament, to the anterior lips of the rami of the pubes and ischia laterally, and anteriorly it is continuous with the fascia of the scrotum. By its junction with the triangular ligament posteriorly it forms a pouch, which is divided into two portions by a median septum.

This pouch has an important influence on the direction urine takes when extravasated, or pus when it forms, in this region. Owing to the attachment of the superficial fascia to the base of the triangular ligament and to the

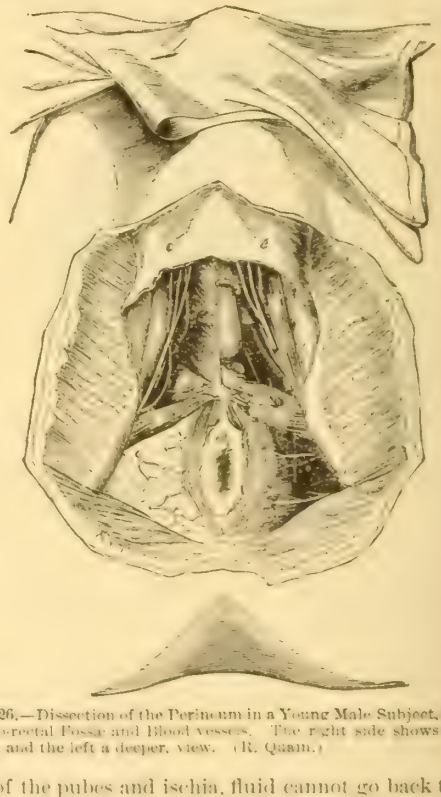

Fig. 2826.—Dissection of the Perineum in a Young Male Subject, showing Ischio-rectal Fossæ and Blood vessels. The right side shows a superficial, and the left a deeper, view. (R. Quain.)

rami of the pubes and ischia, fluid cannot go back toward the anus or down the thighs, but, as the fascia is continuous anteriorly with the dartos of the scrotum, no resistance is offered to its progress forward and upward over the scrotum to the abdomen (see *e*, Fig. 2826).

This is the course taken by urine when extravasated in front of the triangular ligament. When an abscess

forms in the perineum, owing to the median septum it is usually confined to one side of this pouch, and the swelling is triangular in shape. The pus, as it passes forward, on account of the deficiency of the septum in front, fills both sides of the pouch.

Structures in Relation with the Triangular Ligament.—In front are the structures named above as being contained in the perineal pouch.

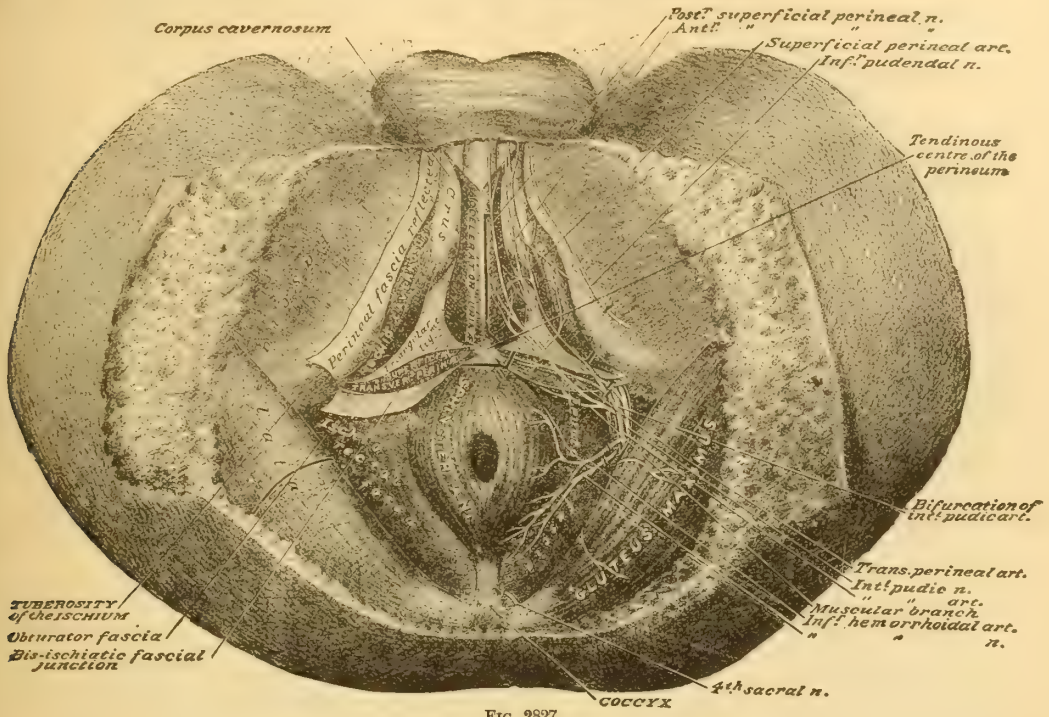

FIG. 2827.

The ligament is pierced by the urethra, and also by the dorsal vein and nerves of the penis and the internal pudic arteries. The urethra pierces the ligament one inch below the symphysis pubis, in the middle line. The parietal layer of pelvic fascia (posterior layer of the triangular ligament) is above and behind, and is attached to the ligament below, but as it proceeds upward the space between them widens. Between these two structures are the membranous portion of the urethra, the pudic vessels

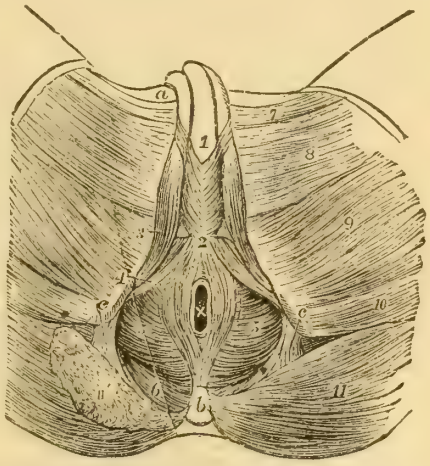

FIG. 2828.—Superficial View of the Muscles of the Perineum in the Male. *a*, Spine of the pubis; *b*, coccyx; *c*, placed on the tuberosity of the ischium, points by a line to the great sacro-sciatic ligament; X, anus; 1, placed on the corpus spongiosum urethræ in front of the bulbo-cavernosi muscles; 2, central point of perineum; 3, ischio-cavernosus; 4, transversus perinei; 5, levator ani; 6, coccygeus; 7, adductor longus; 8, gracilis; 9, adductor magnus; 10, semitendinosus and biceps; 11, on the left side, the gluteus maximus entire; 11′, the same, cut on the right side, so as to expose a part of the coccygeus muscle. (Modified from Bourgery, in Quain's Anatomy.)

The ligament is pierced by the urethra, and also by the dorsal vein and nerves of the penis and the internal pudic arteries. The urethra pierces the ligament one inch below the symphysis pubis, in the middle line. The parietal layer of pelvic fascia (posterior layer of the triangular ligament) is above and behind, and is attached to the ligament below, but as it proceeds upward the space between them widens. Between these two structures are the membranous portion of the urethra, the pudic vessels

Muscles.—The muscles of the perineum bound the perineal triangle, in which the knife is entered in the operation of lateral lithotomy. The base of the triangle is formed by the transversus perinei muscle, the outer side by the ischio-cavernosus (erector penis) muscle, and the inner side by the bulbo-cavernosus (accelerator urinæ); the triangular ligament forms the floor of the triangle.

The point of meeting of the two transverse perineal muscles, the sphincter ani, and bulbo-cavernosus muscles is called the tendinous or central point of the perineum. Along the lower border of the transverse muscles is seen the transverse artery, a branch of the internal pudic.

*Triangular Ligament.**—This ligament divides the perineum into two portions—a deep and a superficial. It has very definite attachments to the subpubic ligament, the rami of the pubes and ischia, and the superficial fascia. It also blends with the central tendinous point of the perineum. As suggested by Professor D. J. Cunningham, of Dublin, it is better to regard this ligament as a distinct membrane, and to class it in the same category as the obturator membrane; for "it lies in the same morphological plane as the bony and ligamentous wall of the pelvis," and it completes the pelvic wall in front in the same manner as the thyroid membrane closes the thyroid foramen.

When the body is erect the lower surface of the triangular ligament looks downward and forward, and the deep surface upward and backward.

* This structure is sometimes named the anterior layer of the triangular ligament, the posterior layer being the parietal layer of pelvic fascia. It is also called the deep layer of the deep perineal fascia and the subpubic fascia.

and nerves, with the artery of the bulb, the dorsal vein of the penis, the compressor urethræ muscle, which surrounds the membranous urethra, and Cowper's glands. These latter empty their secretion into the bulbous portion of the urethra; in inflammatory conditions of the urethra they may become inflamed and suppurate; they are the homologues of Bartholin's glands in the female.

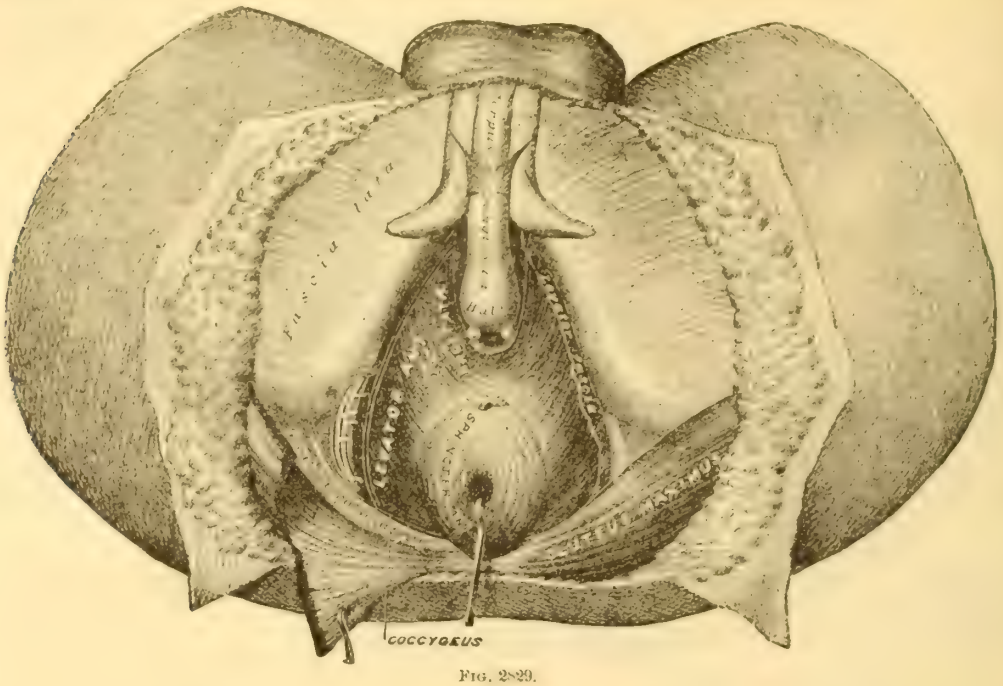

Fig. 2829.

The membranous portion is the least dilatable portion of the urethra, and is frequently the seat of *traumatic* strictures; it measures three-fourths of an inch in length.

Behind and above the pelvic fascia (posterior layer of the triangular ligament) is the apex of the prostate gland, covered by the levator ani muscle and by its own capsule. From this description it will be seen that the triangular ligament divides the perineum into two compartments, a superficial and a deep; the superficial contains the perineal muscles and root of the penis; the deep the membranous portion of the urethra, the pudic artery and nerves, the dorsal vein of the penis, the compressor urethræ muscle, and Cowper's glands. The base of the triangular ligament is the meeting point of three fasciæ, viz., (1) perineal, (2) triangular ligament; and (3) the parietal layer of the pelvic fascia (posterior layer of the triangular ligament).

The triangular ligament sometimes offers an obstacle to the introduction of a catheter; for if the instrument be not kept against the upper wall of the urethra, it is apt to sag in the lower wall, which is very distensible, and reach the triangular ligament below the opening of the membranous urethra. After the triangular ligament has been successfully passed, the point of the instrument may be arrested in the membranous urethra by the spasmodic contraction of the compressor urethræ muscle which encircles it; this obstruction may be overcome, without exercising any force, by merely keeping the end of the instrument pressed gently against the obstructing point; after a short time the muscle relaxes and the instrument slips into the bladder.

Kicks in the perineum, or injuries from falling astraddle of anything, may rupture the membranous portion of the urethra, and in these cases blood and urine will be extravasated between the triangular ligament and the parietal layer of the pelvic fascia (posterior layer of the triangular ligament). Should the injury tear the triangular ligament, then the extravasated fluid would take the ordinary course upward over the scrotum and abdomen. When extravasation has occurred, free incisions should be made in the perineum, and if the

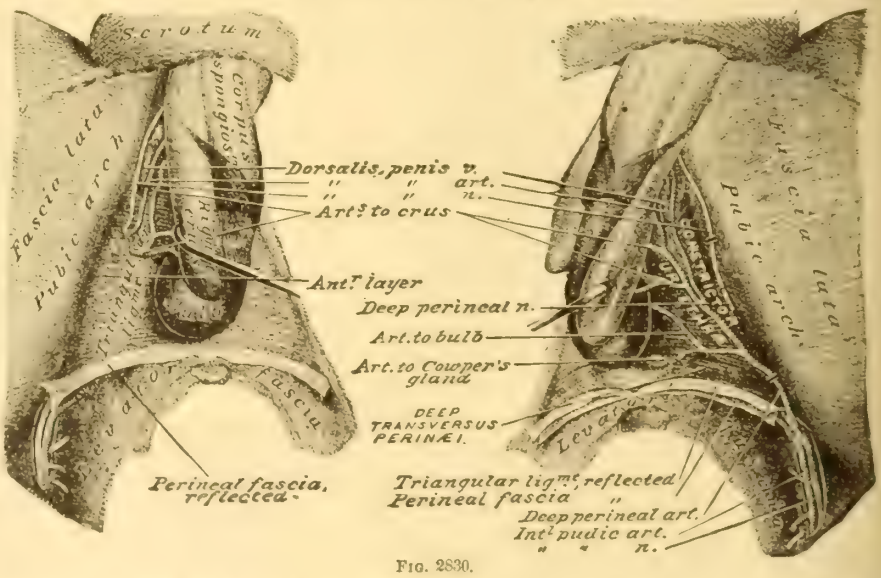

Fig. 2830.

urethra be completely torn across, the perineum should be opened in the middle line and an instrument introduced into the bladder.

Professor Cunningham, of Dublin, has pointed out, in his "Dissector's Guide," that in removing the various structures from the surface to the prostate gland, alternate layers of fascia and muscle are met with, viz.: (1) Superficial fascia; (2) *superficial perineal muscles;* (3) triangular ligament; (4) *compressor urethræ muscle;* (5) parietal layer of pelvic fascia, or posterior layer of the triangular ligament; (6) *levator ani muscle;* (7) capsule of the prostate and pubo-prostatic ligament.

Internal Pudic Artery.—The pudic artery is seen in the rectal triangle, enclosed within a sheath of pelvic fascia formed by the splitting of the obturator fascia. It lies about one and a half inch above the level of the ischial tuberosity, and is accompanied by the pudic nerve and the two pudic veins; proceeding forward, it passes between the triangular ligament and the parietal layer of pelvic fascia (posterior layer of the triangular ligament), and then, running under cover of the rami of the pubis and ischium, pierces the triangular ligament from behind half an inch below the symphysis, and a little to one side of the middle line. It then divides into its two terminal branches, the artery to the corpus cavernosum, and the artery to the dorsum of the penis. The pudic artery, while in the ischio-rectal fossa, gives off the hæmorrhoidal, and a little further forward the superficial and transverse perineal, arteries. While passing behind the triangular ligament, it gives off the artery of the bulb, the wounding of which was formerly so much dreaded by surgeons. The pudic artery itself is said to be in danger of being wounded in lateral lithotomy, but this accident could occur only to the most careless operators, when withdrawing the knife and sweeping it outward. It is only possible to wound it after it has left the protection of the pubic arch.

Exploration of the Bladder through the Perineum.—This operation is little more than a perineal section. According to Sir Henry Thompson, after introducing a grooved staff an incision should be made in the median line, commencing three-fourths of an inch in front of the anus, and the parts should be divided till the staff is reached in the membranous portion of the urethra; the finger is introduced into the bladder through this incision, the prostatic urethra dilating easily; the staff is now removed and the exploration of the bladder is made. Through this median incision tumors and stones of moderate size can be removed. There is little hæmorrhage, even should the bulb be wounded, for this latter structure is not very vascular in the median line.

Parts Divided in Lateral Lithotomy.—The incision is commenced one inch and a half in front of the anus, and is carried downward and outward to a point between the anus and great tuberosity, a little nearer the tuberosity than the anus.* In order to reach the staff in the membranous urethra the following structures must be cut:

In the first incision: Skin and superficial fascia; transverse perineal muscle and artery; base of the triangular ligament; the hæmorrhoidal vessels and nerves.

Second incision: The knife is now guided by the forefinger, passed up behind the triangular ligament, its point placed in the groove of the staff, and the blade is lateralized and pushed along the groove into the bladder. In this incision the following parts are divided, viz.: Membranous portion of the urethra and compressor urethræ muscle; parietal layer of pelvic fascia (posterior layer of the triangular ligament); anterior fibres of the levator ani and left lobe of the prostate.

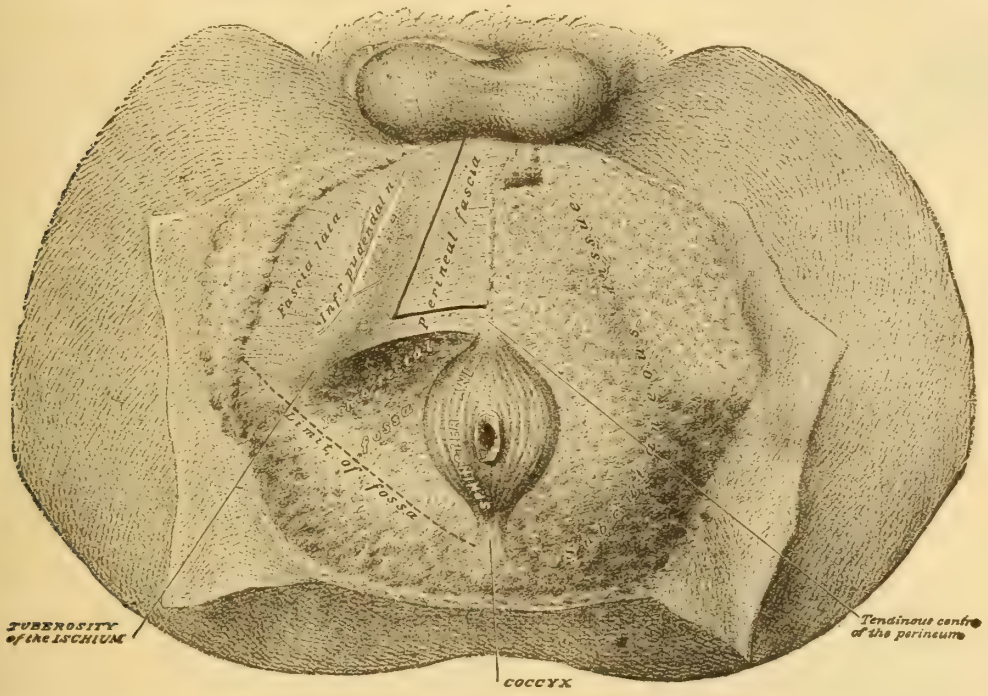

Fig. 2831.

Parts to be Avoided.—(1) Artery of the bulb, (2) rectum, (3) pudic artery.

(1) The danger from a wound of the artery of the bulb is not great, and is somewhat traditional; with the modern methods of arresting hæmorrhages no one need fear wounding the artery of the bulb. Very frequently it is abnormal in its distribution, and its division cannot be avoided.

(2) The rectum may be cut, especially in children, if the bowel is not emptied previous to operation, or if the incision be carried down too vertically.

(3) The pudic artery need never be wounded in a properly performed operation. It can only be cut by lateraliz-

* The incision employed in lateral lithotomy falls about in a line parallel with the ascending ramus of the pubis and the ischio-cavernosus muscle. (Roser.)

ing the knife too much in withdrawing it. If wounded, it may be secured with the modern artery forceps without great difficulty.

In the withdrawal of the knife a too vertical incision may cut through the prostate, and so divide the visceral layer of pelvic fascia. Should this accident happen, no ill results will follow if the wound be kept sweet and be thoroughly drained. Wound of the visceral layer of

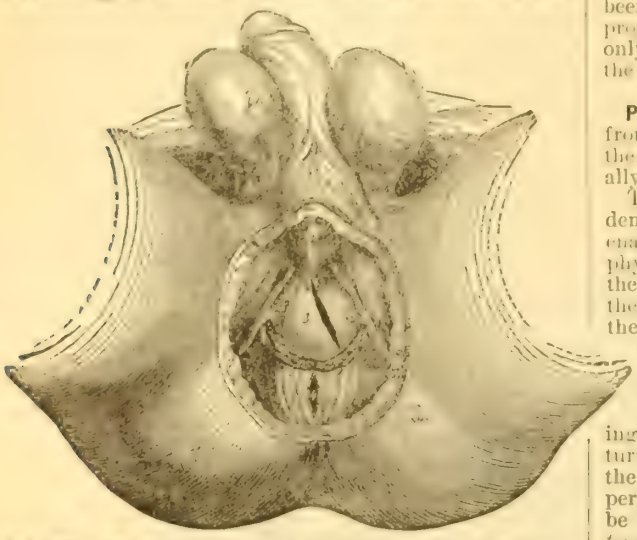

Fig. 2822.—Dissection showing Line of Incision in Lateral Lithotomy. 1, Bulb; 2, membranous urethra; 3, prostate; 4, anus; 5, sphincter ani cut away anteriorly; 7, pudic arteries. (After Roser.)

pelvic fascia is a danger much dwelt on by the older lithotomists, and surgeons of the present day still have a traditional fear of this accident happening. In children, lateral lithotomy can scarcely be performed without cutting through the prostate gland, and at the same time the visceral layer of pelvic fascia; yet no ill results follow; on the contrary, the operation is safer in children than in adults. The real danger in adults arises not from

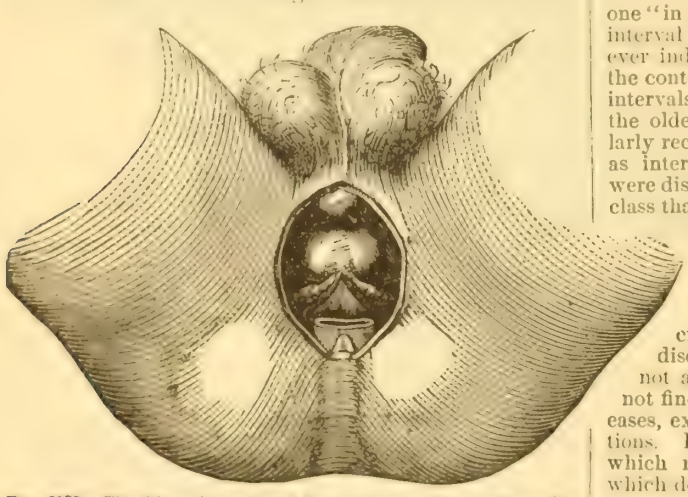

Fig. 2823.—The skin and muscles of the perineal region, together with the end of the rectum, have been removed, and the bulb, Cowper's glands, the prostate, with the seminal vesicles and vasa deferentia are exposed. (Roser.)

wounding the pelvic fascia, but from wounding the prostatic plexus of veins and the ejaculatory ducts.

Testicle in Perineum.—During the descent of the testicle, and after it has passed through the external abdominal ring, it may, instead of entering the scrotum, pass down into the perineum (ectopia perinealis). In these cases it may be felt slightly movable under the skin, about an inch and a half in front of the anus. The scrotum of the side in which the testicle is lodged in the perineum is deficient if the affection be congenital, if the case is of traumatic origin the scrotum of that side is present. The displacement has no evil effect on the testicle, which is always of a good size. The abnormal position of the testicle renders it liable to injury, and patients apply to the surgeon for relief. An operation has been devised for restoring the misplaced testicle to its proper position in the scrotum, but its success has been only moderate. Excision is sometimes demanded to rid the patient of his trouble. *Francis J. Shepherd.*

PERIODICITY IN DISEASE. Periodicity is derived from the Latin *periodicitas*, from *periodicus*, derived from the Greek περί, around, and ὁδος, a way or journey; literally, a journeying around, a circuit (Thomas).

The term periodicity is applied in medicine to the tendency of certain physiological and pathological phenomena to recur at stated times, as is especially exemplified, physiologically, in the recurrence of the menstrual nisus, the monthly maturation and discharge of the ovum, in the periodic need for food, for sleep, in the rhythm of the respiratory and cardiac movements; also, in disease, in the regular recurrence or intermittency of malarial paroxysms, in relapsing fever, and in the intermittent manifestations of certain neuroses, etc.

In a general way our functions are constantly following a circular movement, which causes them always to return to the original starting-point, and to tread ceaselessly the same track, which explains the adoption of the word periodical, as above defined, to designate them. It will be noticed also that we use the words *rhythm*, *intermittency*, and *periodicity* synonymously, an equivalence which is established by authoritative precedent and usage. A slight preference appears to exist in the use of the word rhythm, which is generally preferred by writers (Foster, Griesinger, Spencer, and others) when discussing non-pathological phenomena; while the words intermittency and periodicity are especially employed in dealing with pathological phenomena.

Some of the older writers were at great pains to establish a difference between the words periodic and intermittent. For instance, Senac,[1] Fizes,[2] Voulorme,[3] and Moreau de la Sarthe[4] insist on defining an *intermittent* disease as one "in which something remains hidden or latent" in the interval between the attacks, and even when nothing whatever indicates an occult disease. In *periodic* diseases, on the contrary, they believed that real health existed in the intervals. Casimir Medicus, who was one of the best of the older writers on this subject, wrote that only regularly recurring pyretic manifestations were to be classed as intermittent affections, while the periodic diseases were distinguished by apyrexia; and it is only to this last class that he devotes his attention in his learned treatise.[5] Reydelet[6] accepts and emphasizes this distinction, and follows the example of Medicus in discussing as periodic diseases only those presenting intermittent phenomena without pyrexia. Frank[7] adopted the use of quinine as a criterion between the intermittent and periodic diseases; if quinine failed in the treatment it was not an intermittent, but a periodic, disease. Reil did not find a difference between these two classes of diseases, excepting according to the seat of their manifestations. He taught that intermittent diseases were those which resided in the viscera, and the periodic those which developed in the extremities of the body. These and other similarly curious distinctions prevailed until 1839, when Mongellaz[8] repudiated all of them and considered the two terms *intermittent* and *periodic* as synonymous, a course which was very sensibly adopted by all his successors.

While dealing with the synonymy of the word periodicity, it will be well to remember that the word *period* in disease is used in a distinct sense and signification. Every acute disease characterized by a regular evolution and natural history presents in its course different phases or epochs, during which are effected, in accordance with

a certain order in their development, certain changes or modifications in their intensity, or even in the character of their morbid phenomena. These changes are designated, according to their order of succession, as the period of invasion or development (*stadium incrementi*), maturation (or *fastigium*), indicating the maximum intensity of the morbid process; the period of decline, or defervescence (*stadium decrementi*), which gradually leads to the period of convalescence and the termination of the disease. These are what are called "the periods" of a disease.

These periods, which are easily adapted to the great group of the continued febrile diseases, or the remittent continuous pyrexiæ, such as the exanthematic fevers, might be still further increased by adding the periods of incubation, of prodromes, etc. But instead of increasing, it would be preferable to reduce them; and even to return to the three simple periods of Hippocrates would not be undesirable.

"Jaumes, in his 'Treatise on General Pathology,' abbreviated still more the divisions established by the father of medicine by not admitting more than two periods in disease: (1) the morbid period or period of degradation, first phase of the disease, succeeded, when death did not intervene, by (2) the effort in the inverse sense, *i.e.*, of conservative action, by the period of restoration." This simple division, as Charrin says, "has the advantage of its adaptation to the course of the chronic as well as of the acute diseases, and of realizing with more exactness the analogy which Dumas, in his treatise on chronic diseases, endeavored to establish between the periods of these two great classes of diseases."

In the intermittent fevers, the word stage or *stadium* is preferred to distinguish each of the distinct movements in a paroxysm of this fever, the first characterized by chill, the second by fever, and the third by sweating, corresponding to the three Hippocratic periods of a complete disease.

This much, then, for the "periods" of a disease, which should not be confounded with the periodicity displayed by it; the term periodical disease being applied solely to any morbid complexus which, after ceasing entirely, reappears at stated times, leaving the organism in apparent health during the intervals between its attacks or paroxysms.

Periodic Diseases.—The type of the periodic diseases is the fever known as the malarial intermittent, with its regular paroxysms of short duration, separated by intermissions which are usually less than twenty-four hours in duration, but which may last, according to the different and best known types, one, two, three, four, or five days. But, in addition to this type of periodic disease which is characterized distinctively by the febrile state more or less frankly marked, though sometimes disguised under diverse symptomatic forms, there is quite a group of non-febrile diseases which are also periodical. But the periodicity, in the majority of these cases, is far from displaying the remarkable regularity of rhythm which characterizes the fevers. The duration of the remission, and the frequency with which the attacks or paroxysms are reproduced, vary considerably. There may be several, and sometimes a great number of, attacks in the same day, or the remissions may last several weeks, several months, and even a year, as has been illustrated in many reported cases. It is especially in the class of functional nervous affections which are characterized by the absence of appreciable anatomical lesions, *i.e.*, the neuroses, that this element of periodicity is most frequently noticed.

The neuroses which most often present themselves periodically are: Epilepsy, hysteria, chorea, the majority of the neuralgias—a great many of which are only disguised forms of malarial toxæmia—certain forms of delirium, migraine, nervous or spasmodic asthma, and certain spontaneous hæmorrhages which are dependent on neurotic or neuropathic conditions.

Among the chronic diathetic diseases which assume the periodic type we find rheumatism, gout, and saturnine, or painters' colic.

"Certain chronic maladies which, though dependent on local, permanent, organic lesions, nevertheless present in their paroxysmal manifestations marked intermittencies, which seem to indicate that the somatic lesion is not itself the sole cause of the disease, but that a nervous element is more or less intimately associated with it. Such conditions are notably exemplified in angina pectoris, catarrhal or emphysematous asthma, and in renal asthma. We may also consider as belonging to this class of diseases, which are under a combined neurosis and organic lesion, the majority of the transitory fluxions or hyperæmias, and a certain number of the periodic eruptions."

It is evident, as Charrin[9] says, "that it is only through an abuse of language, or in a purely relative sense, that we can consider as a perfect state of health the interval that intervenes between the spells. Whatever be the calm and well-being enjoyed during these intervals, the disease nevertheless persists potentially, as it is bound, by a certain fatality, to reproduce itself more or less soon, and without the necessary mediation of any new cause." Neither is it necessary that this apparent lull in the symptomatic manifestations be a really healthy state, and that all morbid action cease absolutely during the intermissions.

Axenfeld[10] remarks that such is the rapidity with which a seizure relaxes into calm, and so violent is the contrast between one and the other, that the patient scarcely notices the slight phenomena which are manifested between the attacks, and physicians themselves do not always escape the illusion suggested by this sudden transition from one state to another. It is in this way that, between the paroxysmal attacks of hysteria and epilepsy, not only does the disease undergo a considerable attenuation, but also the disorders which persist between the paroxysms are often considerably modified by the influence of the attacks.

Illustrations of Morbid Periodicity.—Owing to the remarkable indifference with which the subject of periodicity in general is regarded by modern authors, it is not surprising that there should be little effort made by the present school of clinicians to gather illustrative instances of this peculiar mode of morbid action, and that, as a result of this general apathy, the scarcity of illustrations from modern texts should contrast very strongly with the immense wealth of curious cases displayed by the older authors, who, under the collective title of periodic diseases, massed together some of the most extraordinary and varied illustrations of morbid action.

Reydelet[11] takes unusual pains with this subject, and from this writer, as well as from Mongellaz[8] and others, whose works will be found in the bibliographical index, I have selected a number of illustrations which are curious enough to deserve resurrection.

Instances of Periodic Inflammation in Different Parts of the Body. Van Swieten[12] observed in one of his patients a most violent ophthalmia which returned at fixed periods. It began by a slight pain; afterward the eye became red, exophthalmic, and epiphoric, this state lasting for several hours with such intensity that the man became wild with distress. As soon as the pain ceased all the symptoms disappeared, and the eye did not present the least trace of the previous disorder. This would appear to have been a case of ocular hyperæmia associated with a neuralgic condition of the ophthalmic division of the fifth nerve, and which is, in malarial localities especially, almost constantly characterized by intermittence.

Romel[13] speaks of a young girl who, every spring, was attacked by an acute inflammation of one eye. The inflammation began in one eye at first, but was rapidly transferred to the other, and finally returned to the eye primarily affected. This condition lasted sometimes four weeks. "I know a young man," says Reydelet, "who suffered precisely in the same way, only that the duration of the ophthalmia, which returns regularly and unfailingly, varies." Morton and Senac quote analogous examples.

Vandermond[14] mentions a case of periodic coryza which attacked daily one of his patients, aged thirty. The at-

tack began early in the morning and lasted till noon. At this time the face became flushed, the eyes, the nose, and even the frontal sinuses appeared to be congested, and an abundant discharge of a clear and acrid fluid escaped from the nostrils. During the rest of the day and night this man was perfectly well and free from his coryza. Attacks of sneezing, followed by fever (*fièvre sternutative*), and recurring at regular intervals, have been observed in malarial countries in consequence of malarial infection; also certain forms of hay asthma, preceded by violent sneezing and occurring at regular intervals, have been well known to ancient and modern authors. Several cases of periodic urethral discharge have also been recorded, but doubtless most of these owe their periodicity to well known outside agencies, though we should not forget to observe that the inflammations of mucous membranes are most liable to periodic recurrence.

A curious case of periodic non-inflammatory œdema of the upper lip, which came under the observation of the writer, is worthy of notice. The patient was an Italian woman, aged thirty-seven, who, while apparently enjoying the best of health, was seized every morning, for two weeks, with a well-marked swelling of the upper lip. At about 11 A.M., every day, the lip suddenly began to swell, and became hot, turgid, and bluish in color. It was compressible, soft, doughy, and characteristically œdematous, the swelling causing the lip to project nearly two inches beyond the teeth and preventing the patient from speaking distinctly. It was not a painful swelling, and, apart from its alarming appearance and the inconvenience caused by its presence, gave rise to no serious trouble. The enlargement lasted usually about one hour and then gradually disappeared, leaving the patient as well as ever before. In this case there was no organic, cardiac, renal, or other lesion that might give a hint as to the etiology, and it was only because of the regular periodicity displayed by the condition that quinine was administered. After the exhibition of this drug the swelling occurred only every second day, and finally disappeared. It was certainly a mysterious case, and whether it was a malarial manifestation or not is not yet clearly settled in the writer's mind. It is now nearly two years since this occurrence and, though the patient has been seen often by the writer, he has never known her to exhibit any malarial manifestations.

All physicians know that erysipelatous inflammations often affect the periodic type, and that they require the greatest attention at the time of the periodic relapses. Finally, exact observations have demonstrated that a number of internal inflammations may become periodic; and if the examples are not as numerous as in the previous instances, it is because they are not so readily observable. It would, therefore, be impossible to doubt in the least the susceptibility of inflammatory diseases to periodicity.

Neuroses.—Epilepsy is perhaps, of all these, the one which should occupy the first rank. The seizures may come on every hour, every day, every month, with faithful punctuality. Almost all writers on the subject (especially those who wrote in the earlier part of this century, when the subject of periodicity attracted much more attention than it does at present) have noted numerous instances of this kind. Among the old authors, such as Tulpius, Martin, Rouland, and Marcellus-Donatus we find quite a number. Barbet attended a lady who, during a whole year, was subject to epileptic seizures which began regularly at 7 A.M. and ended at 8 P.M., the remainder of the night being passed in rest. Hagerdorn quotes a case which is just the reverse of this—it is that of a woman who, being well during the day, was seized with epileptic movements every night on going to bed, which did not leave her until morning. Blackmore observed epileptic attacks which presented themselves every two days, at a fixed hour, and which lasted exactly four hours. Lanzoni speaks of a nobleman who was attacked every third day. Praetorius saw the affection return once every week at supper time, in the case of a lady who had been thus affected for twenty years. Houlier noted the case of a priest who was attacked every month. Scharschmidt observed the attacks recur every two months, in a man who was seized only when he heard music, which was with him an imperious exciting cause. Hoffman saw them return regularly every three months in a child, as the result of a fright. Westphal, Van Swieten, and Liutaud, saw cases in which the attacks recurred every six months, and Reydelet one in which the interval was a year. Perhaps certain periodic epilepsies which occur in connection with certain particular epochs or events (menses, etc.) might be considered in this connection. Such, for instance, would be a case observed by Gurbetzen, in a woman, a multipara, who always felt very well during her pregnancies, but who in the non-pregnant intervals was subject to epilepsy. An opposite example would be the case of Lanzoni, whose wife became epileptic only when she was pregnant.

Some forms of Jacksonian epilepsy, though not so recognized by the ancients, and classed by them as forms of apoplexy, appear to manifest themselves periodically.

A case in point is cited by Jean Rhodius, and one by Archibald Pitcarinus, who recorded the case of a man who fell insensible, lost speech, and after a convulsive seizure, *which solely affected the right arm*, returned to consciousness. This man was regularly affected in this manner twice a year, in March and in September. It certainly looks like a case of discharging cortical lesion of a periodic character, and is not unlike some forms of this disease noticed in our days.

Hysteria and melancholia are frequently periodic. It has been observed that melancholic patients become distinctly worse in certain seasons of the year which do not vary. Curious accounts of such periodic manifestations will be found scattered in ancient and modern texts on mental diseases.

There are some examples of nymphomania and other forms of erotomania which assume a periodic form. Gaspard Westphal records the case of a young man who, every day from five in the morning till noon, was possessed of violent erotic desires. Vangrado writes of a woman who, after living very chastely with her husband, was seized with excessive passion in the intervals between her pregnancies. At these times she became lascivious beyond expression; but no sooner would she become pregnant than a complete reversion of feeling took place, and she became exceedingly reserved until after her delivery. It is sufficient to observe, for any length of time, the inmates of an asylum for the insane, to assure one's self that the disturbances of the intellectual functions which characterize them may return periodically (*folie circulaire*). These periodic paroxysms and relapses of the insane are so well known, and so frequently observed, that there are few persons, having had any experience in this line of study, who could not cite numerous examples.

Besides these there exist a number of nervous symptoms, such as syncope, reflex, hysterical, and non-hysterical convulsions, which may present themselves periodically, but which it would take too long to relate. I will say only a few words in regard to a species of general tremor, very likely choreic in character, which occurs periodically, and of which several observations have been recorded. Vandermond saw a young man, aged sixteen, who was inconvenienced every night by a painful trembling in the lower extremities; Benivenius saw the same phenomenon return every eight days, at fixed hours, in the case of a youth, as the result of a fright. Finally, Lanzoni observed this general tremor in a woman on the 24th of June of every year; the attack was followed by a sort of stupor. These instances, quoted from Reydelet, are in all likelihood cases of chorea, hysteria, or epilepsy, as we understand these affections to-day; or perhaps they illustrate the convulsive tremor which Hammond has so ably described.

There are certain lethargic stupors and an insomnia which are periodic in their occurrence. Rost[15] saw a locksmith who dropped into a lethargic spell every day after stool. Tambesius saw a young lady, aged twenty-five, who for a long time fell into regular lethargic spells every Tuesday and Friday. Frederick Hoffman relates

the case of a woman, aged sixty, who every six months fell into a stupor which lasted three days. This was followed by a fever which lasted four days, and terminated in a profuse diaphoresis. He speaks also of a man, aged forty-six, who every day at ten o'clock in the morning experienced certain spasmodic movements which were accompanied by somnolence. Finally, Medicus speaks of a woman who slept only every second day.

Periodic Sweating.—Schulz knew a man who was seized regularly every week with a profuse sweat which threw him into great mental agitation. When this paroxysmal sweating did not occur at the stated time the man became very seriously ill. Sylvaticus speaks of a young girl who was taken every month with a considerable diaphoresis which lasted three days.

The point to notice here is that these diverse phenomena are, as a rule, symptomatic, and do not constitute of themselves an essential malady. They are the precursors or symptoms of affections which are latent in the economy, and we should not stop to treat them alone, as independent entities, without tracing them to the primitive cause which has given rise to them.

Hæmorrhage is the most frequent of the different discharges and eruptions that may assume a periodical character. Blancard has related an instance of epistaxis recurring every day as the clock struck each hour. Such hæmorrhages have been known to occur regularly every week or every month. Hæmoptysis is frequently periodical. Sebastian Albrecht speaks of a young man, aged sixteen, who in the space of twenty-eight hours had thirteen attacks, always at fixed hours. In the case of a woman cited by Thompson this form of hæmorrhage occurred every three days regularly, though she menstruated normally. In the case of a man referred to by Amatus Lusitanus it appeared but once a month, and this interval was also noticed in a similar case reported by Mead. Blancard saw it occur every three months in a case in which regular bleeding from piles had been arrested. Gesner noticed a hæmatemesis which occurred regularly every eight days, as a result of violence inflicted on a patient by her husband. We find in the transactions of the "Academie des Scrutateurs de la Nature" several similar examples in which the patients were never seriously inconvenienced. The observations of cases of periodic bleeding from piles are so numerous that it is useless to cite any examples. Of these different periodic losses of blood, many present themselves without any apparent association with the suppression of other normal discharges. Still it is almost the rule for these to be connected with some functional disturbance and, in the female especially, with amenorrhœa.

Many other non-hæmorrhagic discharges may occur periodically. We read in the "Actes des Curieux de la Nature," vol. x., p. 100, of a case of periodical salivation which seized several young girls at the time of their first menses, reported by Materdus Ciliano. Hoier observed this ptyalism in a woman who looked upon it as a certain sign of pregnancy; and Rensner has noticed the salivation occur so abundantly that it could be mistaken for a symptom of mercurialism.

De Vega[16] reports the case of a bishop who, during twenty years, was subject to a periodical emesis which recurred at a certain time every month.

Periodic diarrhœa is quite common, and numerous cases of this kind are reported throughout literature.[17] A case of periodic diarrhœa will be found recorded by the writer in the *New Orleans Medical and Surgical Journal* of 1882.

Certain extraordinary cases of diuresis may also affect the periodic type; these are simply peculiar forms of diabetes. Camerarius noticed a diuresis occurring regularly every fifteen days in the case of an old man, aged sixty-three. Bartholin cites the case of a physician who every month was taken with a very abundant diabetes, which caused him no little inconvenience. Mead speaks of a young girl who, during a great many years, was subject to a polyuria which recurred at fixed epochs. Periodical or cyclical albuminurias which have excited so much attention in recent years are worthy of notice in this connection.

All parts of the body, considered successively, may become the seat of periodic disease. Hemicrania almost always affects this type. The different functional affections of sight, hearing, and smell may be subjected to periodicity, as has been demonstrated by observations. In the chest, as already stated, asthma, nervous coughs, and internal (visceral) neuralgias are often periodic in their occurrence. Stork states that he saw a periodical dropsy, which appeared, disappeared, and reappeared at fixed hours; but this observation, if authentic, is one of the most extraordinary ever recorded. Dyspnœa and cardiac palpitations, whether occurring as simple manifestations of a neurosis or as the accompaniments of organic diseases, are very often periodic. A case of renal asthma, accompanying cirrhosis of the kidney, recently struck my attention by the regularity with which it manifested itself at sundown, rarely waiting later than 7 P.M. for its appearance.

There are certain hiccoughs and sneezing spells which recur periodically, a great number of such observations being found recorded in literature, especially in the old "Actes des Curieux de la Nature," Paris. The diseases of the abdominal viscera—that is to say, of the organs exclusively governed by the sympathetic—have a special tendency to manifest periodicity. In this connection it may be proper to mention the periodical occurrence of abortion in certain females. Reydelet knew a lady who aborted eleven consecutive times, notwithstanding all the precautions taken to prevent the occurrence; and many similar cases will be found in most text-books on obstetrics.

The Doctrine of Critical Days.—Intimately connected with the subject of periodicity, and always deemed a topic of great importance by the older writers who occupied themselves with this subject, is the doctrine of critical days in disease. According to the Hippocratic and Galenical notion, by the term "crisis" was understood a marked change, almost always decisive, which occurred in the course of an acute disease and decided, from that moment, the fate of the patient. As crises were produced at certain moments in the evolution of the morbid condition, it was natural to inquire whether this moment did not coincide in the acute diseases with certain particular and fixed days in their clinical history. As such changes did appear to coincide with particular days, these were distinguished as "critical days." Not only were these changes believed to coincide with particular days, but it was also taught that they followed a certain law of recurrence, which caused them to return at regularly fixed intervals, making them simply slaves of a universal law of periodicity, such as was announced by later observers in modern years. The older writers did not limit their inquiries to the sole investigation of the dates of the critical occurrences, which they believed took place with great frequency, but they hastily concluded that these were the *only* days in which legitimate and favorable crises could be effected, and evidently regarded them as possessed of a certain intrinsic influence or virtue, by which they could determine a favorable or unfavorable issue of the malady. This is, as Hamelin[18] says, the origin of the doctrine of critical days, which cannot be confounded with the "theory of crises" without detriment to the latter, a doctrine which is perfectly independent of the one under discussion, and which is as well established as the other has doubtful reasons for its existence.

The first elements of the theory of critical days can be found in the Hippocratic collection, which presents it, according to the book examined, in various degrees of development. Though the teaching is not altogether uniformly held, even in the writings which have been unhesitatingly attributed to Hippocrates himself,* it may be said in a general way that, according to the school of Cos, the evolution of acute febrile diseases was effected by septenaries (or periods of seven days). These were divided into sub-periods of four days, counting *up to* the third

* Compare in this connection, and from the dogmatic stand-point, the Prognostics, the Aphorisms, and the Epidemics, the authenticity of the other works being contested.

septenary of the disease—that is, the *last* day of a period was also the *first* day of the next, excepting the third period, which began with the second septenary. In these septenaries, the terminal days seven and fourteen were especially those in which the crises occurred. Ordinarily if a crisis occurred on other days than these, a fatal termination was probable, while on the fourth day of the sub-periods or indicatory days were manifested the phenomena *judicatoria critica* of modern German authors, which foretold the coming crisis. Thus, the fourth day was an indicator of a crisis on the seventh, the eleventh of one on the fourteenth, and the seventeenth of one on the twentieth. Finally, according to this doctrine, the odd or uneven numbers exercised a preponderating influence, which was more often favorable than otherwise, on the determination of the critical days; notwithstanding that it is affirmed, in the first book of the "Epidemics" (sec. iii., par. 12, Littré trans.), that the disorders which are intensified on *even* days are to be *judicated* on those days. It may be stated, however, that in view of the contradictions and difficulties of the Hippocratic text, which has remarkably exercised the patience and sagacity of the most learned commentators, it is very difficult to know or estimate the amount of sound observation, or *à priori* meditation, which led to the establishment of this numerical system of prognostics by the Master of Cos. Even the share of originality that is due him as founder of the doctrine of critical days is a matter of some conjecture, particularly when we consider that the genuineness of even the famous letter of Hippocrates to his son Thessalus is denied, this letter having served as a basis to Bordeau and others in their efforts to prove that the famous Asclepiad had received his inspiration from the Pythagorean theories in establishing the doctrine of critical days.

With Galen, who devotes to this question a voluminous treatise in three volumes, the theory was systematized and at the same time complicated. Independently of the crismic, critical, principal, or decretory days, as they were afterward called, and the indicative, contemplative, or demonstrative days, this author admits the intercalated days (third, fourth, ninth, thirteenth, and nineteenth) named later, provocative and irritative (because they provoke the nature of the crisis), in which might be realized favorable but not positive crises; and the empty medicinal days (sixth, eighth, tenth, twelfth, sixteenth, and eighteenth), which have no particular significance, or, if any, a bad one, and in which medicines may be administered without danger. Of these days, some bode good with certainty; the others evil, imperfectly; they do not all have the same importance. In the first rank of the happy days Galen puts down the seventh, which he compares to a good king, and which is imitated especially by the fourteenth day; after this comes the twenty-first, and then follow the ninth, the eleventh, and the twentieth, after which may be placed the seventeenth and the fifth, then the fourth, and finally the third and the eighteenth. Among the bad days there is none that can be worse than the sixth, which Galen accuses of all sorts of evils and regards as a tyrant from whom nothing favorable can be expected. Sometimes the eighth and tenth are as bad on account of the sudden deaths that occur in them, and the same might be said of the twelfth, sixteenth, nineteenth, and thirteenth (vide "Critical Days," book first, chaps. iv. and v.). Finally, as if all these refinements and subtleties were not enough, Galen, in order to harmonize theory and observation, the teachings of the "Aphorisms," of the "Prognostics," and of the special histories of the diseases described in "Epidemics," invents a medical or lunar month, and attributes to sidereal evolutions and influences that which he cannot afford to attribute to the numbers themselves.

It is useless to discuss the basis of this theory which, fortified and amplified by the astrological vagaries and reveries of the Arabs, and of the physicians of the Middle Ages, became a law, notwithstanding many noisy dissenting voices, up to the modern epoch. In fact, we find it still sustained in the first third of this century by Landré-Beauvais (excluding, of course, the astrological explanations), and admitted, though with reserve, by Andral, Graves, and other eminent clinicians. But we can ask ourselves with Forestus, Bordeau, De Haen, Hamelin, and others: "Are there really no fixed moments or days for the determination of those changes which occur in the course of a disease, and which we still know as crises?" Two English writers, Drs Thomas Laycock (1842-43) and Edward Smith (1844), undertook to answer the interrogatory above propounded, by an inquiry into the cause of the phenomenon of periodicity in nature. Laycock, from a general review of the periodical phenomena observed in menstruation, in uterogestation of the human and brute female, in the development of the ova of fishes, and in the metamorphoses of insects, came to the conclusion that physiological changes occur in animals every three and a half, seven, fourteen, twenty-one, or twenty-eight days, or at some definite number of weeks. In other words, he came to the conclusion that there are certain critical days in health—days in which there are marked changes in the vital movements, whether those changes be for the better or the worse, and that these days may be stated generally as the fourth, seventh, fourteenth, twentieth (or twenty-first), and the twenty-eighth. Further, from a review of the periodical phenomena observed in disease, particularly in the groups of the eruptive, intermittent, and continued fevers, and in gout, he endeavored to show that the changes observed in them followed a rule of periodicity similar to that manifested in health. He saw reason, moreover, having regard to the period of three and a half days, or seven half days, to revert to the ancient division of the whole day, *nycthemeron* (νυχθήμερον), into two parts, here following Graves, who had said: "We should not count three days and a half, but seven half days; we should not say seven days, but fourteen half days. If this method were adopted, many of the apparently critical terminations in the continued fevers would, I have no doubt, be found strictly conformable to some regular law of periodicity." Laycock saw reason to revert to the ancient Hippocratic doctrine of critical days in fevers, as already detailed in the preceding pages, which he considered the first and plainest exposition of the doctrine of critical days, and he believed it to be correct. Laycock then proceeded to make a comparison of the critical days of febrile diseases and the order of sequence observed by intermittents, and further, to compare both these forms of fever with the periodicity observed in the exanthemata, and make the facts bearing upon that part of their pathology harmonize with each other. "The critical days, according to Hippocrates (doubtless here writing, without knowing that he did so, of what we now call continued fevers), are, as already pointed out, the first, fourth, seventh, ninth, eleventh, fourteenth, seventeenth, twentieth, or twenty-first. The paroxysms of a tertian will take place thus: On first day, 1 p.; third day, 2 p.; fifth day, 3 p.; seventh day, 4 p.; ninth day, 5 p.; eleventh day, 6 p.; thirteenth day, 7 p.; fifteenth day, 8 p.; seventeenth day, 9 p.; nineteenth day, 10 p.; twenty-first day, 11 p. The paroxysms of a quartan will take place on first day, 1 p.; fourth day, 2 p.; seventh day, 3 p.; tenth day, 4 p.; thirteenth day, 5 p.; sixteenth day, 6 p.; nineteenth day, 7 p.; and if a continued fever existed with tertian or quartan exacerbations, the more violent symptoms might be expected to appear on the days indicated. On comparing the order of days discrepancies between the three are sufficiently obvious on superficial consideration, but many of them disappear on more particular inquiry. . . . With regard to the exanthemata, it will be seen at once that the critical days they exhibit occur on quartan order. Exanthematous typhus exhibits the tertian type, and as might be inferred, the critical days in this fever are the fifth, seventh, eleventh, and twenty-first. Scarlatina is sometimes tertian, sometimes quartan."

In regard to Laycock's observations and opinions, to which we shall have occasion to refer further on, Netten Radcliffe authoritatively says: "Since the discrimination of the several varieties of continued fevers, and after the

date when Laycock wrote, medical observation has not tended generally to support the doctrine of critical days as it relates to this group of febrile disorders, or to confirm the evidence upon which that doctrine appeared to be founded. Murchison's observations[19] did not support the applicability to typhus, but in this respect, as he notes, they were not in accord with the observations of Gardner, Russell, and Traube, of Berlin. The last named, indeed, as also Ziemssen and Wunderlich, may be said to have revived the doctrine (N. Radcliffe). I would note, at this juncture, that, with the advance of clinical thermometry, the use of the terms crisis and critical days is generally restricted to the acute pyretic disorders. Thus, Wagner ("General Pathology," 1879) defines the word crisis in its modern sense as follows: "By the term crisis or resolution we understand an improvement which takes place suddenly in a few (four to twenty-four or twenty-six) hours, and which is accompanied by a sudden fall of temperature (from 2° to 5° C.), and in pulse-rate (from twenty to sixty beats), and also by the occurrence of sweating, sleep, urinary deposits, etc. This is especially illustrated by the supporters of the Hippocratic theory of critical days, by relapsing fever, in which the paroxysm intermits on the third, fifth, or seventh day." According to Murchison[20] the doctrine fails with respect to enteric fever, but he adds that he had often noticed that the disease terminated about the twenty-first or twenty-eighth day. E. Seguin[21] reproduces the views of Hippocrates on critical days and Wunderlich's seeming confirmation of them, himself accepting the similitude, indeed, the quasi-identity, of the results obtained in this regard by the father of physic and the modern professor. According to Wunderlich's observations the majority of cases of typhoid fever run a regular course divided into periods corresponding in time with the division into weeks and half weeks. The ordinary course is about twenty-one days, and Seguin describes an effervescence of seven days, a fastigium of seven days, and a defervescence of seven days, but he adds, with reference to the irregularities which so often mark the disease, "simple as it looks, how difficult it is to make it out!" In typhus—simple uncomplicated cases—the thermometer on the fourth day indicates the height, the sixth and seventh days are regarded as the turning-points, and a perturbatio critica occurs at the end of the second week. "The doctrine of crises," says Wunderlich, "was for the ancients a dogma; for us it must become a law." The observations of L. Thomas[22] and those of Lebert[23] were not as favorable for this theory as were those of Seguin and Traube. Thomas found but one case, out of seventeen subjected to a quasi-expectant therapeusis, that did not terminate on an odd day (between the third and seventh, average the fifth day), but Ziemssen observed a termination on an even day in ninety-five out of one hundred and seven cases.

Hamelin,[18] whose article has furnished the writer with a great deal of the preceding information, states that his observations are in accordance with those of Thomas, and cites sixty-six instances in which the crises occurred on odd days, proving that the chances are pretty well balanced as to whether a crisis will occur on an odd or an even day, and finally lending considerable support to those who believe that the doctrine of special *fixed critical* days in disease is more or less an illusion.

In connection with these views on septenary periodicity, as expounded in the Hippocratic and Galenical formulæ of the critical days, the opinions and observations of some of the American writers on the subject may be interesting. The distinguished Dr. Robert Jackson (1850), of Philadelphia, was of the opinion that the aptitude to receive the morbific impression of the cause of fever more at particular times than at others, is due to the fact that it manifests itself more frequently about the fourteenth day after communication with an infected source, and that it is observed chiefly at septenary periods—the seventh, fourteenth, twenty-first, etc.—from the time of exposure. This opinion was based upon the results of his own observation made upon large bodies of men, upon healthy men placed as attendants in infected hospitals, and upon healthy soldiers sent to malarial districts. Among such, the fever seldom appeared before the seventh day, commonly not before the fourteenth, and, in numerous instances, not till the expiration of six weeks, or even two months, though the cause of the disease during the time was ordinarily in great activity. Another distinguished American writer, Dr. Dickson,[24] of Charleston, S. C., in a like manner pointed out the fact that "the apparent influence upon it (fever) of septenary evolution is familiarly noticed in our climate, where the opportunities for observation are unfortunately distinct. Our country fever is expected to invade on or about the fourteenth day, and if the twenty-first pass without an attack, most persons consider themselves entirely safe."

An anonymous but very learned reviewer in the *North American Medico-Chirurgical Review* for September, 1857, to whom we are indebted for many and valuable data, adds to the above quotation: "Nor has it failed to be noticed that intermittent fevers exhibit during their course a tendency to septenary evolution, and that at those periods, either after the seventh, fourteenth, or twenty-first paroxysm, they have a disposition to terminate spontaneously. This was frequently verified in Florida under Torry's observations, and has been noticed sufficiently often elsewhere to justify its being received as a well-established fact. In remittent fever the same tendency is noticed, the disease having a particular disposition to a favorable critical change on the seventh, fourteenth, twenty-first, or twenty-eighth day." In regard to these last statements we fear that they are not actually justified by the facts, as our experience, and we feel confident that also of the majority of the most experienced practitioners of the South, rarely, if ever, has tended to confirm the statement that a malarial fever of the intermittent type inclines as a rule to spontaneous recovery. If it ever does so, it is only exceptionally, and even then it is exceedingly doubtful whether recovery coincides with heptenary periods.

Theories in Explanation of the Phenomenon of Periodicity.—Periodicity as manifested in the human organism, whether in health or in disease, is a subject which, like many others presenting striking and mysterious characters, has not failed to attract the attention of philosophers in general, and of medical thinkers in particular. In view of the attention devoted to the phenomenon it is not surprising, therefore, that theories and, in most instances, only hypotheses, almost as numerous as those who have directed their attention to the subject, have been formulated to account for it, each theory reflecting with greater or less fidelity the philosophic tendencies of the age in which it originated. For this reason many, if not most, of the theories, and especially the more ancient and mediæval ones, illustrate by their fanciful and at times grotesque character the primitive knowledge and infantile condition of the medical science of their day. For this reason we are not surprised to read of the absurdities of the Galenical theory, of the curious teachings of the notorious Paracelsus, of the peculiar doctrines of Cornelius Gemma and Schenckius, and of the conceits of the humoralists who attributed periodicities of short intervals to thin and subtle humors, and those of longer duration to the thicker and more inspissated fluids.

In the older days the finer rhythms entirely escaped the attention of observers, and they concentrated their efforts upon an explanation of only the gross and palpable periodicities manifested by the diseased organisms, which were solely the outcome of morbid influence. Thus it is that we see so much written on the *cause* of the periodicity of malarial intermittents and comparatively little on the more common and equally remarkable periodicities of the physiological human organism. In connection with the above-mentioned tendency of medical writers, we notice that Erasmus Darwin attributed the phenomenon of intermittence to the nutritive movement of composition and decomposition, and the periodical recurrence of waking and sleeping. Reil taught that it was connected with the analogous phenomena of

the physical universe. Willis referred it to the periodical development of a fermentable matter in the blood; De la Boe, to the introduction into the blood of an acid—pancreatic juice (!); Bouilly, to an irritation of the nerves of the brain and of the fibres of the heart, occasioned by an acidity or an irritating quality developed in the nervous fluid. Werlhoff referred it to the periodical movements of the earth, while Mead and others attributed it, like Galen, to human influence, to the alternate action of day and night, the direction of the wind, etc. Giannini said intermittence was occasioned by the excessive diminution of sensibility during the sweating stage of intermittents. Guérin de Mamers attributed it to an extraordinary development of nervous influence, its concentration upon a given point, its subsequent exhaustion, its renewal, and so on. Mr. Roche finds a sufficient explanation of this phenomenon in the intermittent character of its causes, and in certain other collateral influences. Bailly, nothwithstanding his general good sense, labors through many pages to show that morbid intermittence is occasioned by the diurnal change in the position of the human body from the upright to the recumbent, and *vice versa*. Up to the middle of the present century efforts such as the above were constantly made to account for the phenomenon of periodicity, especially in disease. Then from sheer exhaustion came the reaction, and we find that some of the ablest of systematic writers acknowledged their inability to cope with the mystery, and professed a complete agnosticism as regards its primary causation.

Maillot himself, to whom we are indebted for the preceding condensation of opinions, thus concludes, by quoting the following from Montflocon: "To know that we know nothing is a great deal; we are nearer then—much nearer—the truth than when we mistake for this latter erroneous hypotheses."

As a more striking example of this reactionary class of writers, I cannot avoid quoting the following lines from the work of that now old, but clear-headed, authority, Dr. Elisha Bartlett,[25] in which he says:

"Some of my readers, especially the younger ones, may be not a little disappointed that I do not engage in the attempt, so often undertaken, to lift the veil which hides from us the efficient causes, the mechanism, and the essential nature of this mysterious and complex phenomenon of periodicity. For their gratification, and, I trust, for their benefit, I shall make two or three remarks on this subject, which, unlike the subject itself, will at least be sufficiently intelligible.

"First, then, *all* the interpretations and explanations which have been given of this phenomenon are entirely and absolutely hypothetical; they are the creatures of the brain, the fruits of the imagination, the fancy. Not only so, but in most cases they are obviously and glaringly absurd, preposterous, and false as they are hypothetical. They have not even the merit of possibility, to say nothing of probability, plausibility, or ingenuity. Nowhere, perhaps, in the boundless region of medical speculation has the rage for hypotheses been wider and crazier than here. Secondly, the essential nature of this phenomenon is probably inscrutable: we may analyze it, we may resolve it to its elements, we may ascertain the relations of these elements to each other and to their modifiers—we may do all this, and still be as far as ever from its ultimate cause, its essential causation, its intimate or absolute nature. Who understands, or can comprehend even, the nature of sleep? And what reason is there to believe or to hope that the darkness which has ever wrapped, and which still wraps, this intermittent physiological phenomenon, so full of mystery and wonder, will ever be dispelled?"

And now, after the lapse of thirty one years since the above was written, can we say that we have advanced further than did Dr. Bartlett toward the longed-for explanation?

Here is what Sir Joseph Fayrer,[26] who is the most eminent English authority on periodic diseases, and a most competent exponent of the views held at present by the profession, says on the subject:

"I doubt if any right explanation of periodicity in disease will be given until we can explain it in health—until we can give the physiological rationale of the cardiac, respiratory, or catamenial rhythm, of the diurnal pulse and temperature wave, and so on. We can only say that certain conditions are induced by poisons or impressions acting on the centres, which in one case modify, in another altogether derange, the normal rhythm, substituting for it altered temperature, tissue change, and exaggerated neuro-dynamic states, as seen in the paroxysms of an ague or in the thermic wave of a remittent fever."

The conquests which have been recently achieved by bacteriological science, and which would appear to throw so much light on the etiology of disease, have been utilized by many enthusiastic bacteriologists in explanation of the periodicity of several diseases, prominent among which are the malarial and relapsing fevers. In the first, the *palmella* of Salisbury; the *Bacillus malaria* of Klebs and Tomasso-Crudeli; the *oscillaria* of Laveran and Richard; and the *Plasmodium malariæ* of Marchiafava and Celli (lately confirmed by Sternberg, Councilman, and Osler), have been successively appealed to to explain, by their cyclical development in the organism, the periodic occurrence of malarial paroxysms. Leaving out of consideration the objections that spring up against the immediate acceptance of the view, we can simply dismiss the parasitic theory of malarial periodicity as one which is still distinctly *sub judice*. The existence of the *Spirillum Obermeieri*, which is well proven to be so constantly associated with the paroxysms of relapsing fever, the spirillum disappearing in the intervals; and, again, the still more palpable association of intermittent chyluria and lymph-scrotum with the hæmatozoön, *Filaria sanguinis hominis*, described by Manson, Mackenzie, and others, would greatly strengthen the opinion of those who hold to the microbic explanation of recurrent and periodic infectious diseases. But if we admit that this is the case, that these periodical affections owe their intermittent character to the periodic development of these micro-organisms—a view which, in the case of the intermittent fevers especially, is open to serious objection—can we say that we are finally solving the question? Certainly not. Leaving out of consideration the fact that the nervous system is alone quite competent, without the assistance of any microbic elements, to imitate, and that very closely, the paroxysms of a malarial intermittent *—we could ask how are the equally typical periodicities exhibited by the neuroses—hysteria, epilepsy, and other non-microbic affections already enumerated in a preceding section—to be accounted for? Again, how are the periodicities and cyclical movements exhibited by the normal organism—the esoteric periodicities of Laycock—to be explained? Surely not by the germ-theory. That micro-parasites do play an undoubted rôle in the production of some of the morbid periodicities, such as relapsing fever and intermittent chyluria, is very possible; but the exact mechanism of their action is far from being well understood, as we are almost totally in the dark as regards the actual life-history of most, if not all, of the pathogenic micro-organisms.†

What, then, are the causes of morbid intermittency?

The latest writer, Charrin,[9] thus expresses himself: "It is evidently associated—though this does not make the explanation any easier—with the general periodicity which characterizes the majority of our physiological functions, with the vital acts of which intermittence is one of the essential characteristics, as well as with the periodicities of the great cosmical phenomena and with the frequent changes in the surrounding media." This

* See an account of some remarkable experiments performed by M. Brashet, of Lyons, in 1822; Recherches sur les fièvres intermittentes. Archives Générales de Médecine, vol. xi., 345.

† Again, even if we do admit the influence of the cyclical development of micro-organisms in the causation of periodic diseases, are we not simply shifting the explanation a little further? True, it will be a step gained, but shall we not be confronted by precisely the same problem when we ask ourselves, "Why is it that these micro-organisms (the malarial, for instance) are so *cyclo* periodic in their evolution and history? What is the cause of *their* periodicity?"

opinion, which is simply a modified combination of some of the older theories (Hildebrandt's, Guérin de Mamers's, and Henle's), only serves to indicate how indefinitely and unsatisfactorily this phenomenon is accounted for by the medical mind of the present day.

In summarizing the status of the question as presented by the physiologist, I will state that it is only since our experimental resources have been perfected, and especially since the introduction of graphic, thermometric and other delicate physical means of investigation, that we are able to appreciate innumerable subtle periodicities which are being continually exhibited by the organism, that were entirely undreamt of by the older observers, and which, in fact, are still in process of investigation and elucidation. Without attempting to enumerate them, we would simply state that the cycle of the day is manifested in many other ways than by the alternation of sleeping and waking, with all the indirect effect of these two conditions. There is a diurnal curve of temperature apparently independent of all immediate circumstances, the hereditary impress of a long and ancient sequence of days and nights. Even the pulse, so sensitive to all bodily changes, shows, running through all the immediate effects of the changes of the minute and the hour, the working of a diurnal influence which cannot be accounted for by waking and sleeping, by working and resting, by meals and abstinence between meals. And the same may be said concerning the rhythm of respiration and the products of pulmonary, cutaneous, and urinary excretion. There seems to be a daily curve of bodily metabolism which is not the product of the day's events. Within the day we have the narrower rhythm of the respiratory centre, with the accompanying rise and fall of activity in the vaso-motor centres. And, lastly, as the fundamental fact of all bodily periodicity, is that alternation of the heart's systole and diastole which ceases only at death. Though the intermittent flow in the arteries is toned down in the capillaries to an apparently continuous flow, still the constantly repeated cycle of the cardiac shuttle must leave its mark throughout the whole web of the body's life. Our means of investigation are, however, too gross to permit us to trace out its influence. Still less are we able, at the present day, to say how far the fundamental rhythm of the heart itself, that rhythm which is influenced but not created by the changes of the body of which it is the centre, is the result of cosmical change, the reflection, as it were, in miniature, of the cycles of the universe, or how far it is the outcome of the inherent vibrations of the molecules which make up its substance (M. Foster).

In conclusion, we would state that the data herein presented, and much more that the limits of this article will not permit of mention, tend to prove that the phenomenon of periodicity is one of the best marked characteristics of our vital activities, and demonstrate that we, in our organic acts, are no exception to that universal law which, manifesting itself throughout nature—whether in the cycle of the planetary movements, whether in the rolling of the ocean billows, whether in the peaceful ripple of a brook, whether in the flux and reflux of the tides, whether in the more subtle undulations of the thermic and luminous rays, or in the more secret vibrations of the ganglionic cell—always proclaims that rhythm is a necessary characteristic of all motion—a resultant of conflicting energies, "an irresistible corollary of the persistence of force" (Spencer).

[1] De recondità feb. intermitent. naturâ. [2] Traité des fievres.
[3] Mémoires sur les fièvres intermittentes.
[4] Encyclopédie methodique. [5] Les maladies périodiques.
[6] Article Maladies Périodiques, Dict. Encyclop. des Sciences Médicales, 1821. [7] Traité de Méd. Pratique.
[8] Les Irritations Intermittentes, 1839.
[9] Dict. Encyclopéd. des Sciences Médicales, article Périodicité, 1887.
[10] Treatise on the Neuroses. [11] Dict. des Sciences Medicales, 1819.
[12] Comment. Aphor., Boerhaave, 2. p. 354.
[13] Dict., iii., Ann. ii., p. 330. [14] Recueil Périodique, vol. vi., p. 196.
[15] Collect. Breslau, vol. xv., p. 204. [16] De Cartis Medendi.
[17] See Breslau's Collection; and also the Actes des Curieux de la Nature. [18] Dict. des Sciences Medicales, Dechambre; article Crise.
[19] Treatise on the Continued Fevers of Great Britain, second edition, p. 181. [20] Ibid., p. 547. [21] Med. Thermometry, 1876.
[22] Archiv für Heilkunde, 1864-65.
[23] Handbuch der Praktischen Medizin.
[24] Elements of Medicine, second edition, p. 179.
[25] The History, etc., of the Fevers of the United States. Fourth edition. 1856.
[26] Sir Joseph Fayrer, M.D., F.R.S., etc.: On the Climate and Fevers of India. Being the Croonian Lectures delivered at the Royal College of Physicians in March, 1882.

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* The contributor is indebted to the kindness of that invaluable friend of all medical writers, Dr. John S. Billings, for the major portion of the references.

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Rudolph Matas.

PERITONEUM (*τὸ περιτόναιον δέρμα*, from *περιτείνω*, to stretch all round or over; Lat., peritonæum; Fr., péritoine; It., peritoneo; Ger., Bauchfell). The lining membrane of that part of the cœlom or body cavity situated below (caudad from) the diaphragm. Being composed of a thin layer of flattened endothelial cells, it readily permits the extravasation of liquid, and is normally moistened by a slight quantity of serous fluid;

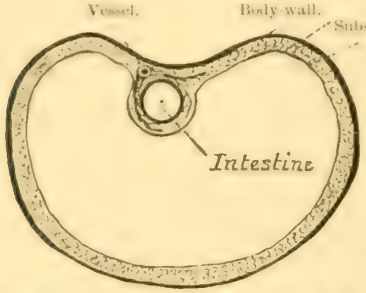

Fig. 2834.—Diagram showing a Cross-section of the Body. The cœlom is in its simplest form, with the peritoneum investing the cavity and the external and internal tubes closely applied to each other.

hence it is characterized as a serous membrane, and the cavity which it encloses as one of the great serous cavities of the body, the others being the two pleural cavities, the pericardial cavity, the cavity of the arachnoid (subdural space), and that of the tunica vaginalis testis. Excepting the subdural space, which is a doubtful member of the group, all of these are derived from the cœlom.

It will be recollected that the mesoderm splits into a visceral and a parietal layer. The folding over and closing of these two layers at the median line on the ventral surface forms two tubes, one contained within the other, with a cavity separating them. The inner, or enteric tube, is the alimentary canal; the outer, or somatic tube, the general body-wall; the closed space between is the cœlom, and its lining is the peritoneum.

It is without opening in the male, but in the female certain secondary modifications occur by which

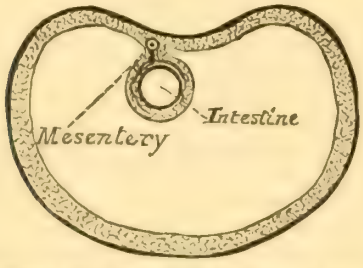

Fig. 2835.—The Same, showing the Mesentery in the Process of Formation.

the originally complete sac loses its continuity. Upon the ovary it thins away and finally disappears, leaving a bare surface ready to shed the ova, and at the abdominal openings of the oviducts or Fallopian tubes it becomes pervious, reminding us of the arrangement in lower vertebrates in which the ova are shed into the peritoneal cavity and leave it through openings in the wall called abdominal pores. This arrangement accounts for the occasional occurrence of abdominal pregnancy, the ova not being seized by the fimbria of the oviduct; and it should also be remembered that by this avenue fluids may pass from the cavity of the uterus through the oviduct to the peritoneal cavity, and that inflammation may also be propagated from the oviduct to the peritoneum.

In the original and simplest condition the two tubes formed by the cleavage of the mesoderm are united at the dorsal side. This is shown in Fig. 2834, and it will be seen that the peritoneum passes from the body-wall directly over the intestine, and serves as a means of con-

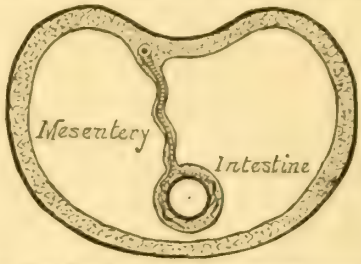

Fig. 2836.—The Same, with the Mesentery completely formed.

fining it. The membrane lining the inside of the wall is known as the parietal layer, that reflected upon the outer portion of the enteric tube and its appendages is the visceral layer. Were the two tubes of the same general length and relative situation throughout, this simple condition would remain. But owing to the need for an increased surface for absorption, the growth of the entire tube is much more rapid than that of the body-wall. It therefore becomes longer, and is necessarily thrown into convolutions which withdraw it from the wall. Its investing peritoneum must follow it, for it is in the connective tissue accompanying that membrane that are formed the vessels for the supply of the digestive tube, and for withdrawing from it the elaborated products of digestion, and it is also by this avenue that the nerves reach the intestine. Fig. 2835 shows this condition commencing; Fig. 2836, completed.

The peritoneum is drawn out into a double fold which may be short, giving but slight mobility to the gut, or

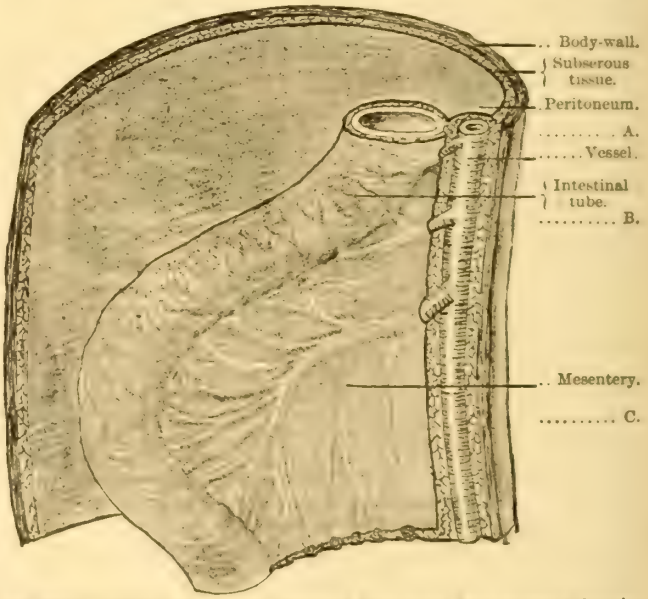

Fig. 2837.—Diagram of a Vertical Section of Part of the Body, showing the relations of the somatic and enteric tubes, and the formation of the mesentery.

longer, allowing a considerable degree of movement. The double fold is characterized by the term meso (*μεσος*, middle), prefixed to the name of the viscus which the tube represents. Thus mesentery is the fold enveloping the intestine, mesogastrium the stomach, and mesocœ-

cum, mesocolon, mesorectum, mesonephron, mesometron, and mesovarium * are also used. Fig. 2837 shows the three conditions just described in a vertical view, which indicates more clearly their relations with each other. In this, Fig. 2834 would represent a cross-section at A; Fig. 2835 at B, Fig. 2836 at C.

The digestive tube by its increase in length, therefore, becomes attached in a series of loops, each having its peritoneal covering and attachment. These loops are not without a certain regularity. Since the peritoneum is essentially a membrane for the support and transference of vessels, the situation and character of these vessels have much to do with the size and arrangement of the loops.

There are originally three distinct regions of the tube corresponding to different fœtal conditions, and supplied by different vessels. Before the closure of the body-wall the middle region is a widely open cavity, connecting with the yolk-sac, or vitellus; the anterior or upper region, and the posterior or lower region, are diverticula from this, and are tubular from the first. The middle region is supplied by the superior mesenteric artery, orig-

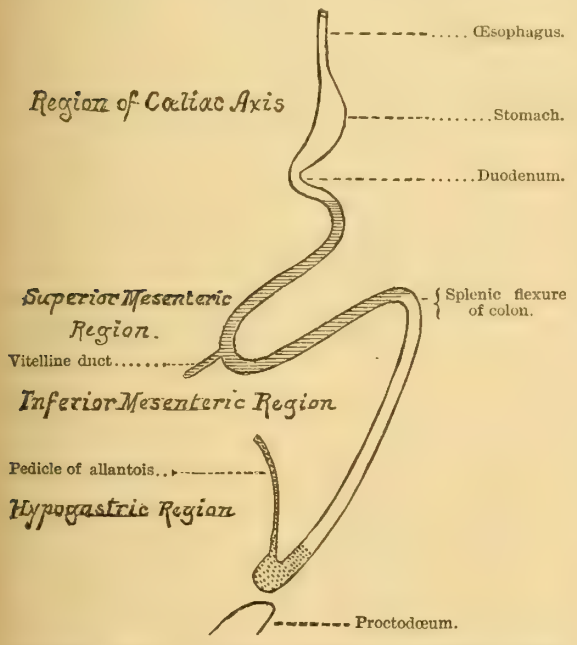

Fig. 2838.—Diagram of the Simple Condition of the Intestine immediately after its Formation, showing the Three Regions.

inally one of the vitelline arteries; the anterior region by the cœliac axis; the posterior by the inferior mesenteric artery. The difference originally impressed remains throughout life, affecting even the functional activity of the regions; for the anterior may be considered as in general chylopoietic, the middle as assimilative, the posterior as excretory.

Besides these, there are in front two areas which have some features produced by the vestiges of vascular conditions which predominated in fœtal life. These are the region of the umbilical artery, and that of the umbilical vein.

The first four of these regions are shown upon Figs. 2838, 2839, and 2840. Fig. 2838, represents the alimentary canal at an early stage, but after the body-wall has closed in. It will be seen that it is composed of three loops, the first corresponding to the region of the cœliac axis. In this the canal lies close to the body-wall at either end (œsophagus, duodenum), while in the middle it is comparatively free. In the second loop (superior mesenteric region) it is similarly confined. The primitive intestine is here represented, however, before any differentiation between large and small intestine has occurred. The lower end of this loop is at the point that afterward becomes the splenic flexure of the colon, and here again the peritoneum becomes closely attached to the body-wall. The fold that represents that attachment is known in the adult as the phrenocolic, or costo-colic ligament. At the bight of the loop the vitello-intestinal duct joins, connecting primitively at the umbilicus the intestinal cavity with the yolk-sac. Here, too, the vitelline vessels enter. This union disappears usually before birth, but traces of it may occasionally be seen in the adult, as a diverticulum of the small intestine. The most frequent cause of umbilical hernia is the persistence of the fœtal condition here described. The third loop constitutes the remainder of the intestinal tube, and becomes closely attached to the body-wall at either end (descending colon, second portion of rectum).

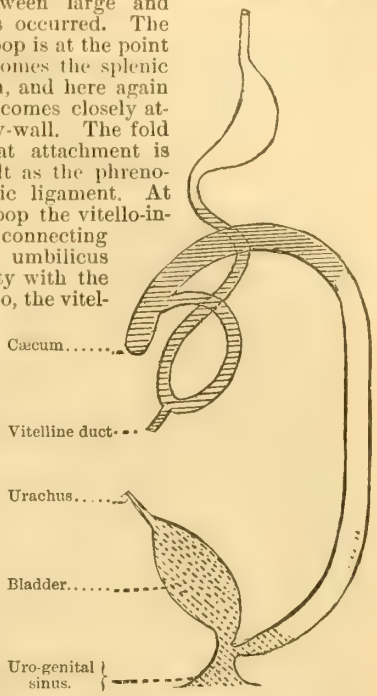

Fig. 2839.—The Tube at a Later Stage. Differentiation of large and small intestine.

This originally simple condition changes somewhat as the intestinal tube continues to grow in length. In the first loop the stomach increases in size, and the liver relatively decreases. This occasions a pull upon the duodenum, which gives it its horseshoe curve and draws it over transversely to the right, carrying with it the stomach which, on assuming its transverse position, turns over to the left so that the great curvature is directed downward. Provision must also be made for very considerable variations in the capacity of the stomach, as it becomes an organ which is to retain a large mass of food for a considerable time. The bight of loop belonging to it becomes, therefore, much looser than at any other place in the canal, and hangs down from the viscus like an apron, forming what afterward becomes the great omentum (see Fig. 2843). Modifications also occur in this loop, because of the development of glandular organs, liver, spleen, etc. These will be described hereafter.

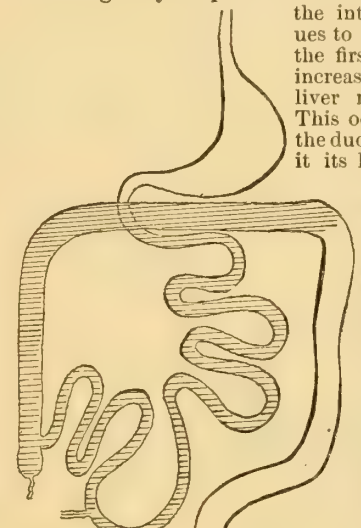

Fig. 2840.—Differentiation of the Bladder, Urethra, and Anus. The loops have assumed their definitive position.

In the second loop a differentiation occurs between

* This combination has been extended to include cases where a similar anatomical arrangement occurs, but which are not immediately connected with the peritoneum, as mesorchium, mesotenon.

large and small intestine. Originally the loop lies in such a way that the descending limb is on the right, the ascending limb on the left. The small intestine is chiefly formed by the descending limb, and its convolutions increase with so much greater rapidity that they crowd the ascending limb and its portion of the large intestine over to the right, so that the comparatively unconvoluted colon comes to span over the folds of the jejunum and ileum (see Figs. 2839 and 2840).

In the region of the ascending colon, the more rapid lateral increase in the body wall and in the size of the right kidney, causes the peritoneum to be used more for the parietal clothing than for the formation of mesentery. The right mesocolon becomes, therefore, more and more reduced, until the intestine when distended becomes stripped of peritoneum behind, and adheres to the body-wall by connective tissue only, being comparatively immovable. A small pocket in the mesentery near the cæcum (fossa subcæcalis) is the remains and indication of the once freer condition. Since the cæcum always arises as an outgrowth after the loop is formed and upon the side opposite to the mesenteric attachment, it usually escapes the denudation of its peritoneum.

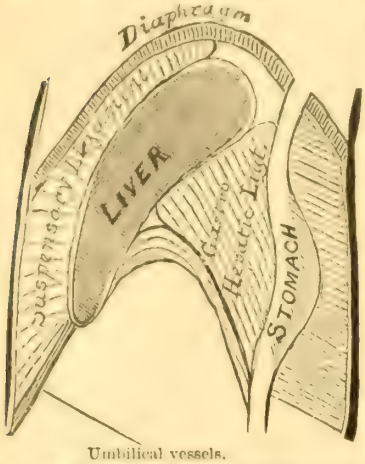

FIG. 2841.—Diagram of an Antero-posterior Section of the Body in Fœtal Life, showing the Course of the Peritoneum from the Spine to the Umbilicus. (Gegenbauer.)

In the third loop (region of the inferior mesenteric artery) a similar reduction of the mesocolon takes place, by which the descending colon is attached to the wall, the sigmoid flexure remaining free, and a relic of this is a similar pouch known as the fossa subsigmoidea. These are sometimes of importance, as the intestine may become entangled in them and obstruction ensue.

From the lower part of the tube the peritoneum is reflected upon the parts which, in the adult, belong to the pelvic floor, and thence upon the anterior wall of the abdomen. In this course it is again subject to certain modifications, because of the vascular supply. From the lower tube the allantois buds off and carries its vessels, the hypogastric arteries, through the umbilicus as far as the placenta. The lower part of the pedicle of the allantois expands, and becomes the urinary bladder (see Fig. 2839). The upper part remains as the urachus, a cord of condensed connective tissue passing from the apex of the bladder, to the umbilicus in the middle line, and lifting up the peritoneum in its course (see Fig. 2846). In the same way the hypogastric or umbilical arteries pass on either side from the internal iliacs, along the side of the bladder, to the umbilicus, also lifting the peritoneum. When at birth these become functionally inactive, the upper part shrinks to a cord of connective tissue, while the lower remains pervious as the superior vesical artery. The triangular fold of peritoneum embraced between the two obliterated arteries and covering the urachus, is described by English anatomists as the superior false ligament of the bladder. It is preferable, however, to discard that name, and to speak of it as three folds of the peritoneum — urachal fold, and right and left hypogastric folds.

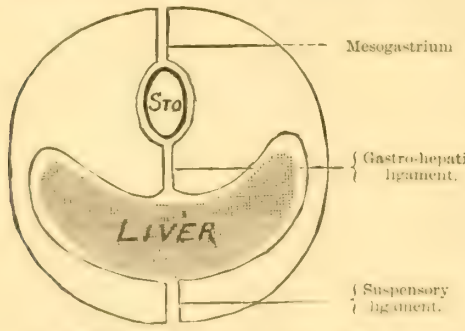

FIG. 2842.—Cross-section of the Same. (Gegenbauer.)

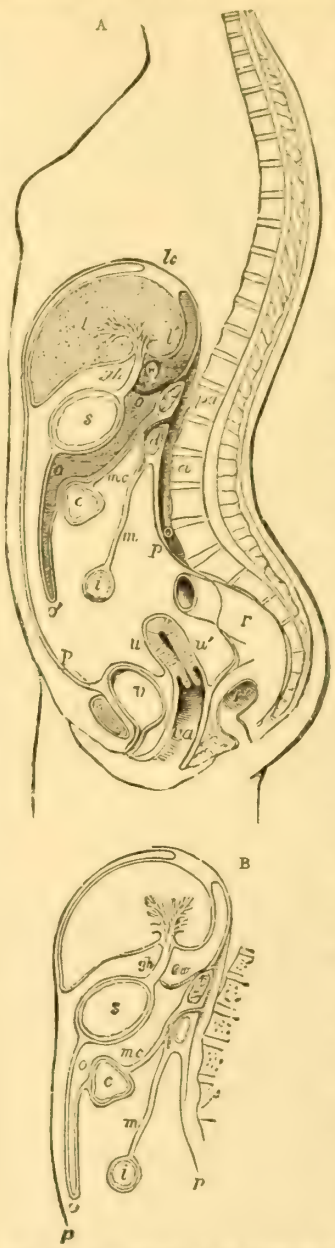

FIG. 2843. A.—Diagram of an Antero-posterior Section of the Body, showing the Reflections of the Peritoneum in the Female. The upper part of the section is supposed to be a little to the right of the mesial plane; below the liver it is mesial. *lc*, coronary ligament; *l*, liver; *s*, stomach; *c*, transverse colon; *i*, small intestine; *pa*, pancreas; *o*, aorta; *d*, duodenum; *r*, rectum; *u*, urinary bladder; *u'*, uterus; *v*, rectum; *va*, vagina; *pp*, parietal peritoneum; *gh*, gastro-hepatic omentum; *ω*, great omentum; *o'*, its cavity, the lesser sac of the peritoneum; *mc*, transverse mesocolon; *m*, mesentery. B is a sketch of a section similar to that of A, showing the turn of the transverse mesocolon and the posterior fold of the great omentum. (Allen Thomson in Quain's Anatomy.)

Having now made the circuit of the abdominal parietes and arrived again at the first of our regions, it will be necessary to consider some modifications introduced here by the development of the liver, which were not mentioned at first for fear of confusing the reader.

The development of the liver takes place at first symmetrically with regard to the intestinal canal, arising as two bodies, one on either side the digestive tube just below the diaphragm. It is clothed by the peritoneum like the other appendages of the canal, and receiving blood from the umbilical vein on the one side, and the portal vein on the other, it comes to lie in the middle of an antero-posterior duplication of the peritone-

um, passing from the stomach forward to the anterior abdominal wall. We thus have the mesogastrium, a double fold leaving the posterior wall and embracing the stomach, then another passing from the lesser curvature of the stomach and from the duodenum to the liver, and containing the hepatic artery, the portal vein, and the hepatic duct, and known as the gastro-hepatic and hepato-duodenal ligaments; then another passing from the liver

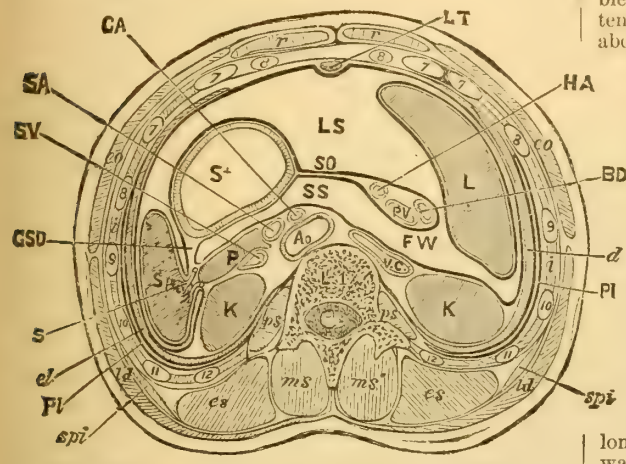

Fig. 2844.—Diagram of a Horizontal Section through the Abdomen at the Level of the Foramen of Winslow. L1, First lumbar vertebra; 12, 11, 10, etc., ribs; *r*, rectus muscle; *eo*, external oblique; *ld*, latissimus dorsi; *spi*, serratus posticus inferior; *i*, intercostal muscles; *es*, erector spinæ; *ms*, multifidus spinæ; *ps*, psoas; *d*, diaphragm. Ao, aorta; VC, inferior vena cava; CA, coronary artery; SA, splenic artery; SV, splenic vein; S, splenic vessels cut as they enter the spleen; HA, hepatic artery; PV, portal vein; BD, common bile-duct; L, liver; LT, round ligament; St, stomach; Sp, spleen; P, pancreas; K, kidney; LS, large sac of the peritoneum; SS, small sac; SO, gastro-hepatic omentum; GSO, gastro-splenic omentum; FW, foramen of Winslow; Pl, pleura. (R. J. Godlee in Quain's Anatomy.)

to the abdominal wall, known as the suspensory ligament and containing the umbilical vein. This is clearly shown in Fig. 2841, and the continuity of the whole system is evident in Fig. 2842.

It will be seen that the upper part of the abdominal cavity is divided into two chambers which, at an early period, are symmetrically disposed. This symmetrical arrangement soon disappears, however. The liver becomes relatively smaller and is displaced to the right, carrying the hepato-duodenal ligament with it, which, in its turn, pulls on the duodenum. The stomach turns over to the left and becomes transverse, so that its greater curvature looks downward, and the mesogastrium stretches out into the great omentum as before described. The consequence of this is that the right cavity comes to be almost entirely enclosed, communicating with the general cavity by a contracted orifice bounded above by the liver, below by the duodenum, in front by the hepato-duodenal ligament, and containing the bundle of hepatic vessels. This orifice is known as the foramen of Winslow, and the cavity which is prolonged down behind the stomach into the folds of the loosely hanging mesogastrium is called the lesser sac of the peritoneum.

The cavity of the right side is, on the contrary, widely opened by the pulling over of the stomach, and is not distinguishable from the general body cavity. Both together are accordingly known as the greater sac of the peritoneum. The way in which one is insinuated behind the other will become evident on consulting Figs. 2843 and 2844.

A further change that takes place in the course of development is that the transverse mesocolon, which is at first entirely independent, finally becomes united with the posterior fold of the great omentum, so that it appears to be embraced by it. This is apparently the result of close application of the two surfaces. The earlier and later conditions are shown in Fig. 2843, A and B.

Having thus seen how this complicated membrane is formed from a simple beginning, it remains to consider more attentively some general points and the special anatomy of the different regions.

The general character of the membrane should be remembered, for it is upon this that its peculiarities depend. In structure it is essentially connective tissue, a fine plexus of white fibres superficially and a considerable number of elastic fibres deeper. This gives it its extensibility and adaptability. No matter how much the abdomen may be distended by pregnancy or by ascites, the peritoneum returns to its normal size when the distending body is removed. When organs are displaced the peritoneum stretches and follows them; when they return to position it returns also, its elasticity enabling it to do this without wrinkling. Hence it occurs that the so-called cavity of the peritoneum is only a virtual one, for when the organs are in a state of health, the parietal and visceral layers are closely applied to each other. In case of effusion into the sac the layers are at once separated and the cavity becomes real. The membrane is extremely rich in blood-vessels; in fact, they are formed in it with great rapidity, and while light gray in appearance when in an inactive state, it becomes quickly reddened by inflammation. Besides the blood-vessels there are great numbers of lymphatics. All this makes it particularly liable to inflammatory processes, and although surgeons have no longer that extreme dread of interference with it that was the rule before the advent of antiseptic methods, it is still considered important to understand its relations sufficiently to make that interference no more than is absolutely necessary.

Different animals appear to have different susceptibilities with regard to the propagation of inflammation in this membrane. The horse shares with man the great susceptibility just mentioned, while the cow and the dog endure large wounds involving it without incurring serious risks. It is perhaps possible that individual variations exist in man, as suggested by Tillaux. One reason for the remarkable properties which it shows is its peculiar relations to the lymphatic system. Over the fibrillary layers just described, there is, as already mentioned, a layer of flat endothelial cells set together by their edges.

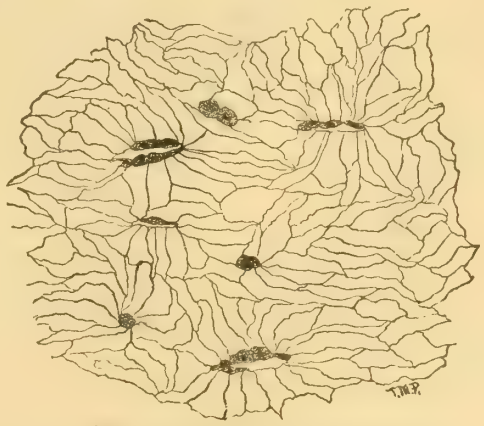

Fig. 2845.—Germinating Cells of the Peritoneum.

In certain situations, especially on the diaphragm, these endothelial cells show areas which have in them thicker granular cells, which Klein calls germinating cells (see Fig. 2845).

These frequently surround microscopic orifices called stomata, which communicate with lymph sinuses. The descent of the diaphragm induces a kind of pumping or suction action which tends to draw into those sinuses any fluid which may be in the peritoneal cavity.

The parietal peritoneum lies upon a layer of loose connective tissue intermingled with fat, which is known as

the subserous layer (fascia endoabdominalis). This has an intimate connection with the visceral layer of peritoneum, and it is because of this that it is possible to produce modifications in the circulation of the stomach and intestines by applying cups, leeches, blisters, and cataplasms externally. Pus collecting in this loose tissue is apt to burrow extensively, but does not usually cross the median line behind, being arrested by the thick processes of fascia which contain the great vessels and serve as their sheath. The amount of the subserous tissue varies in different localities, being considerable along the abdominal wall, over the iliac fossæ, and in the lumbar region, forming there a special investment for the kidneys known as the adipose capsule, and which Langenbeck called the lamina peritonei externa. The entire region from the duodenum down is known as the retroperitoneal space, and in certain cases there has been noted hernia of the intestine into it. Over the central tendon of the diaphragm and at the umbilicus the subserous layer is wanting. Accumulations of fat in this tissue may produce rounded elevations of the peritoneum known as plicæ adiposæ, and this subperitoneal fat may be pushed out between the muscles of the belly wall, forming an adipose hernia. In the lower part of the abdomen the weight of the viscera has caused the layer to become somewhat more dense and to assume a membranous form. It is thus found in inguinal and crural herniæ, forming what is known as the fascia propria. Where this tissue lines the pelvic cavity it is, of course, liable to injury from pressure of the child's head during delivery, and also from bruising by instruments. It is in this tissue that occurs the inflammatory affection known as pelvic cellulitis.

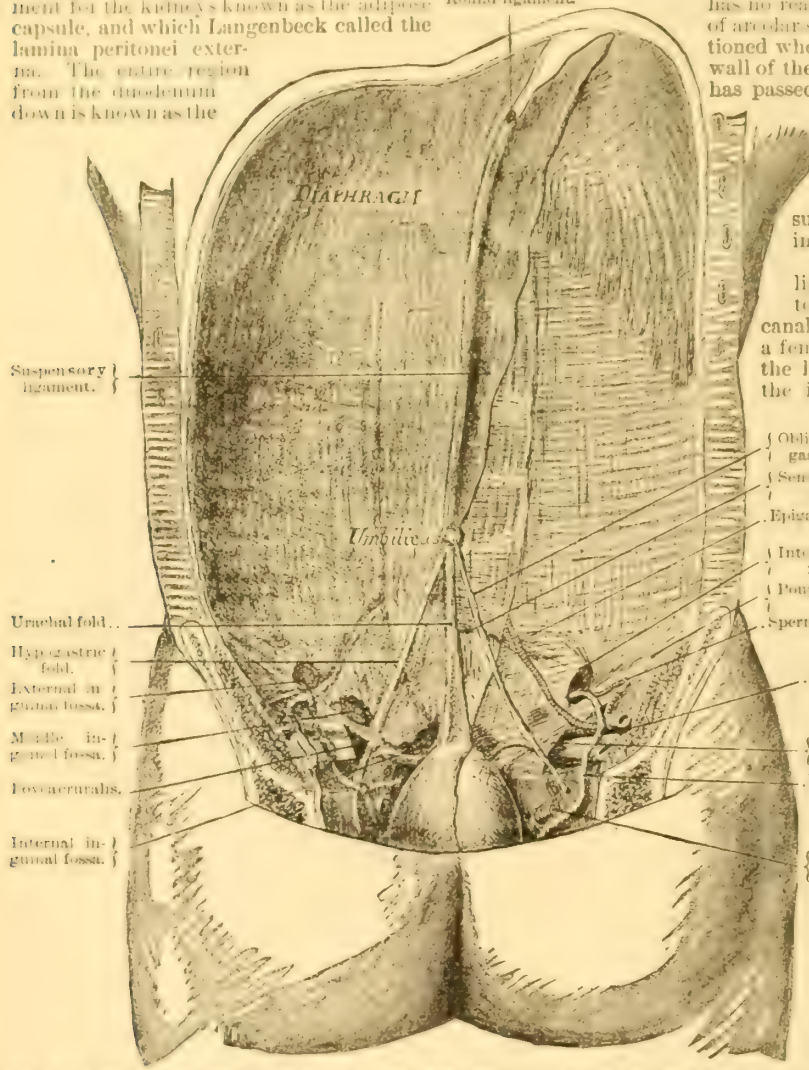

FIG. 2846. Diagram showing the Anterior Wall of the Abdomen as viewed from the Inside after the removal of the Viscera. On the right the peritoneum is removed, on the left it is intact.

In front of the bladder the subperitoneal tissue is especially loose and yielding, giving an opportunity for that organ to expand upward. This peculiarity led Retzius to describe here a "preperitoneal cavity" (cavum præperitoneale, cavum Retzii), which he imagined could be inflated and receive a considerable quantity of fluid. Hyrtl also followed him and described for this cavity a mouth bounded by the semi-circular lines of Douglas, which he called the porta vesicæ. The cavity has no real existence, being merely a succession of areolar spaces. Nevertheless, cases are mentioned where a catheter, having penetrated the wall of the membranous portion of the urethra, has passed up into this tissue, simulating an entrance into the bladder (Illiacx).

It is upon the anterior wall of the abdomen that there are found some impressions of the peritoneum which are of considerable surgical importance. These are shown in Fig. 2846.

We have first below, under Poupart's ligament, the impression corresponding to the abdominal end of the crural canal, usually a mere dimple; this is where a femoral hernia pushes out. Then above the ligament there are three impressions, the inguinal fossæ, lying between the three folds which have been described. In the external fossa there shows a whitish cicatrix, not infrequently a somewhat funnel-shaped depression (foveola inguinalis). It is open in fœtal life, and is the abdominal end of the inguinal canal through which the testis descended. When a hernia pushes through here the depression becomes an opening, the internal abdominal ring. A hernia here is *external*, being to the outer side of the epigastric artery.

The middle fossa corresponds internally to the external abdominal ring externally; a hernia pushing through here is called direct or *internal*, being on the inner side of the epigastric artery.

The internal fossa is not apparent when the bladder is distended. Hernia is extremely rare here, and when it does occur is not usually distinguished from a direct hernia, though some authors call it internal oblique, as it has to take an oblique course outward to reach the scrotum.

The umbilicus appears, when viewed from its peritoneal side, as a depression with a ring-like edge, deeper above than below, from which diverge the four folds of peritoneum already described, three descending to the bladder, one ascending to the liver. As it is here that all the tissues of the body-wall are soldered together, a real umbilical hernia can have no fascia propria, but the peritoneal covering must be immediately next the fibrous tissue which represents the muscles of the body wall. Congenital herniæ usually arise from some defect in the closure of the body walls at the umbilicus, and therefore pass directly through the ring between the three converging vessels, while acquired herniæ—which are caused

by pressure, and particularly from repeated pregnancies, —usually pass out above the umbilical vein.

Passing up along the wall, the peritoneum is finally reflected upon the surface of the diaphragm. There is here also a weak spot in the wall, between that portion of the diaphragm which is attached to the sternum and that which goes to the ribs. Not infrequently the pleura and the peritoneum are here brought together.

On consulting Figs. 2843 and 2847 it will be seen that a considerable portion of the diaphragmatic surface is bare of peritoneum. The anterior sheet is reflected from the diaphragm upon the convex surface of the liver, and in a similar way the sheet from behind is also reflected upon the posterior upper edge of that viscus. These together form the coronary ligament. Between its folds,

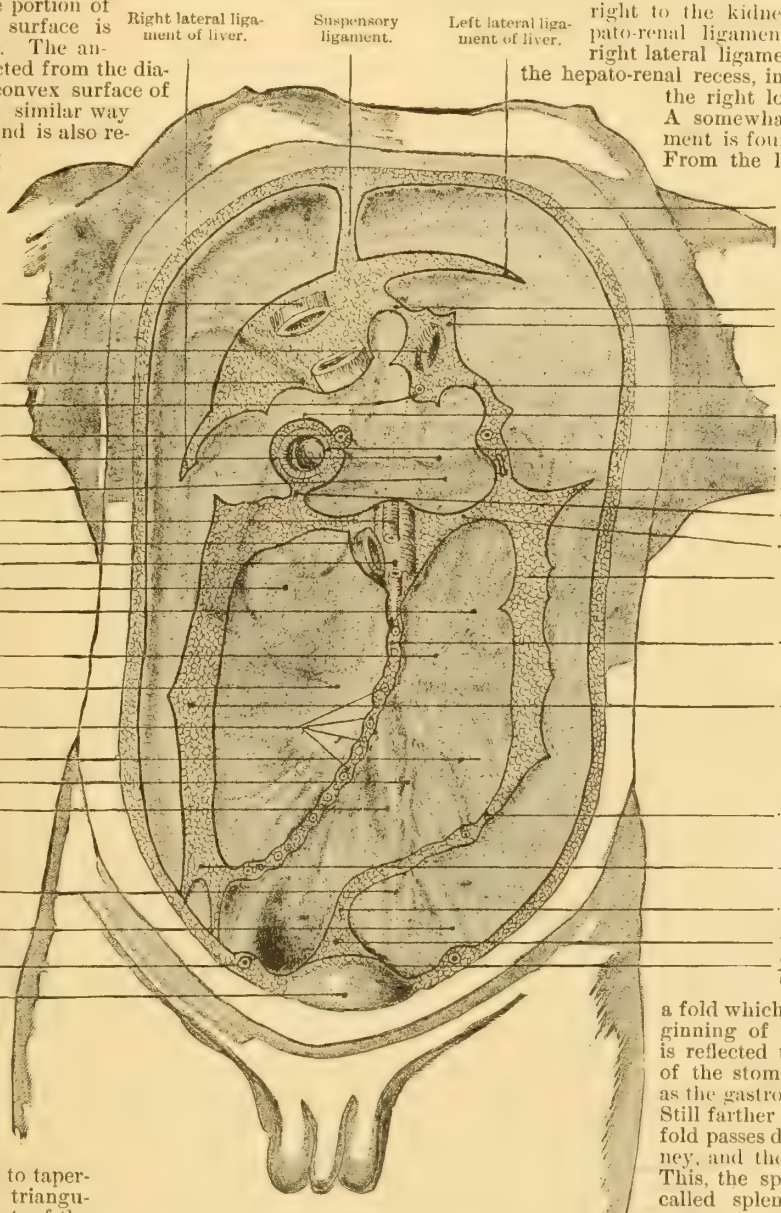

Fig. 2847.—Diagram showing the Posterior Wall of the Abdomen with the Lines where the Parietal Layer of the Peritoneum is reflected upon the Viscera.

and at the point where the suspensory ligament joins it, is found the inferior vena cava. Laterally it is prolonged at either end to tapering folds, called the triangular or lateral ligaments of the liver. Of these the left lateral is by far the best marked, and contains the left hepatic vein. It is in this that are usually found some remains of the former large relative size of the liver; the reduction of its volume having left here some remains of bile-ducts (vasa aberrantia), and there being frequently bursæ formed (Bb. phrenico-hepaticæ.)

From the coronary ligament the peritoneum is reflected upon the upper and under surfaces of the liver. The sheet clothing the upper surface turns around the anterior edge, and thence along the under surface to the porta or transverse fissure where the vessels enter, meeting here the other layer which has approached it from behind.

In its course it is reflected over the gall-bladder, which is usually invested only as to its fundus and inferior surface, the upper surface being attached to the liver by connective tissue. In some individuals, however, the investment is complete, a mesocyst is formed, and the gall-bladder becomes somewhat movable, as is the case in some lower animals. This thick sheet passes off on the right to the kidney, forming the hepato-renal ligament, which with the right lateral ligament forms a pocket, the hepato-renal recess, in which the end of the right lobe of the liver lies. A somewhat similar arrangement is found on the left side. From the left lateral ligament a fold which represents the beginning of the mesogastrium is reflected to the cardiac end of the stomach. It is known as the gastro-phrenic ligament. Still farther to the left another fold passes down upon the kidney, and thence to the spleen. This, the spleno-phrenic (also called spleno-renal ligament, suspensory ligament of the spleen), may be seen in the diagram, Fig. 2844. Still farther over toward the side a process of peritoneum passes off the lower edge of the diaphragm to the transverse mesocolon. This, the phreno-colic ligament (Fig. 2847), forms the splenic recess (saccus lienalis), in which lodges the spleen. Indeed, this little shelf-like pocket affords real support, as may be seen in those cases in which the spleen becomes dislodged from it. Through the stretching of the gastro-splenic omentum it may then become so far displaced as to be found in the right iliac fossa, and other far removed regions of the abdomen.

As has been mentioned, the anterior and posterior investing layers of the liver meet at the transverse fissure of that organ. From thence they pass to the lesser curvature of the stomach as the gastro-hepatic or lesser omentum (see Fig. 2843). After investing the stomach, these two layers pass down in a loose fold known as the great omentum, then upward again to invest the colon, and back to the spine as mesocolon transversum. In the fœtus, as before mentioned, the ascending layer may be traced back to the spine independently. The omental sac thus enclosed is a network of vessels with considerable quantities of fat. It varies considerably in size, appearance, and situation, and indeed it owes its name to this variability, which man shares with the lower animals; for it was upon it that the haruspices relied principally for their prognostications—hence omentum, from omen. It may appear as a broad apron, nearly concealing the entire abdominal contents; or it may be small, reduced, and shoved up so as to leave the intestines almost entirely exposed; or it may be partly concealed among the convolutions of the small intestine. Hyrtl thinks that a considerable displacement is usually found with those who have had a severe struggle in the death agony. It is frequently found in a hernial sac; always, it is said, in umbilical hernia when not congenital. In cases of ascites it is usually floated upward, and it may plug up the incision made for tapping. It may become attached by inflammatory adhesions, giving rise to bands which may confine a knuckle of intestine, and thus occasion a concealed hernia. The omental sac is usually incomplete in adults, as the endothelium thins away and disappears in spots, leaving openings so that what remains is a mesh-work rather than a sac. On the other hand, cases have been reported in which it remained thick and strong, and in which, the foramen of Winslow becoming occluded by inflammatory action, there remained a complete sac filled with dropsical effusion (hydrops saccatus). [? Malgaigne.]

At the fundus of the stomach, on the left side of the omental sac, the peritoneum meets the vasa brevia and the splenic vessels, and passes over them to the spleen, which it invests, and then returns, forming the gastro-splenic omentum (see Fig. 2844). From the lower part of this a fold passes to the tail of the pancreas and the wall (pancreatico-splenic ligament). A similar fold on the right side passes over the coronary artery obliquely, from the cardiac orifice of the stomach to the pancreas (gastro-pancreatic ligament), and divides the cavity of the sac into a small upper region behind the liver and the lesser omentum, and a large lower one behind the stomach and great omentum.

We have now reached the body-wall behind at the attachment of the transverse mesocolon. Here the duodenum is closely bound down against the spine, and the hepato-duodenal ligament passes to the liver over the hepatic vessels, forming the anterior and lower border of the foramen of Winslow (see Fig. 2847).

The duodenum is supposed to end at the commencement of the mesentery, which is the origin of the superior mesenteric artery. It is at this point that Treitz discovered a considerable bundle of muscular fibres passing back from the muscular coat of the duodenum to the cœliac axis and superior mesenteric arteries. This "suspensory muscle of the duodenum" is to be regarded as of the same nature as the subperitoneal sheet of muscle-fibres found in some vertebrates, especially near the genital organs. Similar traces of muscle-fibres are found in the broad ligament of the uterus, and in the ileo-cæcal fold hereafter to be mentioned.

The pulling over of the duodenum causes the peritoneum to be thrown into relief over the superior mesenteric vein as it passes upward to form the portal. This fold is united with another made by the left colic artery from the inferior mesenteric. The two pass from the duodenum to the jejunum, and are known collectively as the duodeno-jejunal fold. The little pocket which lies behind this (duodeno-jejunal recess) is notable for being an occasional seat of concealed hernia. It has been seen sufficiently large to contain the entire small intestine, which therefore had a special sac of its own. This sac was formed, of course, by a hollowing out of the loose tissue of the retro-peritoneal space.

With the superior mesenteric artery, at about the second lumbar vertebra, the mesentery begins. Its attached part or root extends down and to the right to the sacro-iliac joint, where it unites with the ascending colon (see Fig. 2847). The abdomen is thus incompletely divided into a right and left space, and an effusion upon the right will pass to the right iliac fossa only, while one on the left will descend into the pelvis. As the folds of the intestine are many times larger than the root, the mesentery is plaited and ruffled very much like the shirt-front and cuffs worn by our grandfathers, and the French anatomists sometimes speak of it as "la manchette." It contains fat, mucus, blood-vessels, nerves, and absorbents, besides many lymphatic (mesenteric) glands. It will be remembered that it was in the mesentery that Asellius first discovered the lymphatics, or, as they were first called, chyle-ducts.

It is to the length of the mesentery that the intestine owes its great mobility. In cases of very large hernia, the gut has been known to pass downward as far as the knees. It is said that fat is not found in the mesentery until the seventh or eighth month of fœtal life, and that this is of value in determining the age of a fœtus. Tillaux states that there is within the mesentery a considerable number of muscular fibres, and explains thus the withdrawal of the intestine from the abdominal orifice, which takes place when an artificial anus is formed.

The ascending and descending colon are invested by peritoneum only on their anterior surfaces when distended, but when contracted they may appear entirely invested, or even to have a short mesocolon. The cæcum is usually completely invested, as is also the vermiform process, which has a little fold running out to it from the mesentery, known as the mesenteriolum. From the ileum to the cæcum passes the ileo-cæcal fold, which forms, with the mesenteriolum, a little pouch, the ileo-cæcal, which may become sufficiently enlarged to receive a knuckle of intestine.

At the sigmoid flexure the intestine becomes freer, and possesses again a mesocolon, while at the rectum it gradually disappears in the pelvic cavity, its investment leaving it gradually first behind, then on the sides, then altogether, making a triangular fold, the mesorectum.

From this portion of the wall the peritoneum is in the male reflected forward on to the bladder, forming the recto-vesical pouch; in the female upon the vagina and uterus, forming the recto-vaginal pouch (also called recto-uterine, or pouch of Douglas), limited on the sides by semi-lunar folds containing muscular fibres (retractores uteri of Luschka), which pass from the uterus back to the sacrum. The recto-vaginal pouch may contain a coil of intestine, and being the most dependent portion, usually collects any effusion from the left side of the abdominal cavity. From the sides of the uterus the peritoneum passes in broad folds (broad ligaments) outward to the sacro-iliac joints. These contain the annexes of the uterus, ovaries, Fallopian tubes, round ligament of the ovary, etc. That portion of the upper region not occupied by the Fallopian tubes is known as the infundibulo-pelvic ligament.

From the anterior portion of the uterus the peritoneum is reflected upon the bladder, forming the vesico-uterine pouch. In ordinary conditions of the uterus this is merely a slit, the walls being approximated, but in retroversion it may be sufficiently enlarged to receive a coil of intestine, and care should, therefore, be used in operating in this region.

The course of the peritoneum from the bladder to the anterior wall has been described. Laterally it passes outward, forming folds which are known as the lateral false ligaments. It should be noted that when the bladder is distended, it is practicable to enter it above the pubis without wounding the peritoneum. The operation of supra-pubic lithotomy was formerly more used than it is at present.

Frank Baker.

PERITONITIS, ACUTE AND CHRONIC (Fr., Péritonite Aiguë, Péritonite Chronique; Ger. Acute Bauchfellentzündung, Chronische Bauchfellentzündung).

I. Acute Peritonitis.

Acute peritonitis must be described under the two headings of Diffuse and Localized, or Circumscribed.

Acute Diffuse Peritonitis.—The peritoneum being the largest serous surface in the body, its inflammation assumes a high degree of importance. When the inflammatory action is at all extensive, the condition is a very grave one.

Etiology.—Probably it may occur idiopathically. This is certainly very rare, but an attempt to prove the negative of this statement will be found to be a very difficult undertaking.

The more carefully the autopsies of these cases are conducted, the more frequently will some obscure underlying cause be determined, as is being shown by reported cases every day. Still cases have occurred, in the hands of very competent and careful observers, where no possible cause could be found after the most exhaustive research. I have met with a few examples of this kind. Until we have further light, we must allow for the rare occurrence of the disease idiopathically.

At present it is impossible to explain the reason why it is so rare to have idiopathic inflammation of the peritoneum, and why idiopathic inflammation of other serous surfaces—pleura especially—is so frequent.

Idiopathic peritonitis has been attributed to cold, injudicious diet, etc., but the operation of such influences is very problematical. A peritonitis may be set up by the irritation of various diseased processes. It may be thus called into activity by mechanical pressure or friction of a tumor, by an enlarged cancerous organ, by an accumulation in the bowels, or by inflammation and its results in subjacent parts. In this way, a strangulated hernia or intestinal obstruction may cause a very severe form of peritonitis.

The exciting cause may, at the autopsy, be very evident, while, on the other hand, it may require the closest scrutiny for its discovery.

A ruptured gland may originate the whole mischief, and yet readily escape detection. It is, moreover, possible for inflammation to extend through the diaphragm from the pleura or pericardium, although this is very rare.

Peritonitis is often due to perforation or rupture of some parts or organs. The forms of perforation are chiefly as follows: Of hollow viscera, with escape of contents; of solid organs which have undergone softening and ruptured; of collections of fluid or pus in connection with some neighboring parts, or with the peritoneum itself; of collections of fluid in the chest (*e.g.*, empyema, hydatid cysts, etc.). The inflammation in these cases depends upon the irritation produced by the contact of gases and fluids with the peritoneal surface—the most virulent being urine, putrid pus, and gangrenous ichor.

Traumatism may cause peritonitis. As regards wounds of the peritoneum, the wonderful success of modern abdominal surgery has removed the fear of cutting into this membrane which our forefathers held, and has clearly demonstrated that the peritonitis which so frequently followed operative procedures was, in reality, due to the entrance of septic matters.

Peritonitis almost surely follows severe injuries (lacerated wounds) of the peritoneum.

Violent blows upon the abdomen may cause peritonitis through ruptures of blood-vessels, or without the intervention of such an accident.

I have seen an example of the latter. A young man, while playing foot-ball, received a severe blow in the abdomen. General peritonitis developed rapidly, which proved fatal in a few days.

Diseased conditions of the blood are frequent causes of *secondary* peritonitis. The chief of these are septicæmia, pyæmia (puerperal peritonitis), Bright's disease, the eruptive fevers, especially small-pox, and perhaps rheumatism. It is a remarkable fact that peritonitis from rheumatism runs a very favorable course.

Among the predisposing causes must be reckoned sex. It is much more frequent in females than in males, owing to the complicated structures in the pelvic cavity of the former. As regards age, the disease is not frequent in children. It is, however, not rare in infants from infection being carried by the umbilical veins. It occurs during intra-uterine life.

Previous attacks predispose to peritonitis.

Pathological Anatomy.—On opening the abdomen the condition most uniformly present is that of very great distention of the large and small intestines by gas. The peritoneum is injected, perhaps moderately, more often in an intense degree. Extravasations occur in spots.

The injection is found to vary at different parts, being most severe in the locality where the inflammation originated. Plastic lymph is seen covering, in greater or less extent, the membrane upon which it forms a thin, grayish-yellow covering, readily detectable and loosely connecting adjacent parts together. Blood-stained serous fluid is early poured out. This serum may go on collecting until found in very considerable quantities—so-called *exudative peritonitis*. When plastic lymph is in excess and the quantity of serum slight, we have the so-called *adhesive peritonitis*.

Small collections of pus are frequently found between matted knuckles of intestine. Pus formation in the structure of the peritoneum is very rare. Gangrene is seldom seen, except in patches from twisting of the bowel, and when the peritonitis has arisen from a foul abscess or from urinary or fæcal infiltration.

The effused matters in peritonitis vary much both in quantity and in quality.

The fluid in the abdomen may be limited to a few ounces, or it may be so excessive as to displace the diaphragm and abdominal organs.

In the dry form we find an extensive continuous false membrane investing the abdominal viscera. As the disease advances, connective-tissue formation goes on and results in adhesions between coils of intestines and organs.

Adhesions may be permanent, or, owing to the great mobility of the abdominal viscera, they may be separated, stretched, or reduced to mere cords or bands.

Adhesions may subsequently give rise to various disturbances of function owing to constriction or displacement of parts included within their grasp. In the most exaggerated cases, false membrane binds the whole of the abdominal viscera together till they are all smelted indissolubly in a mass the one with the other. Small quantities of fluid may be found in meshes of the false membrane, and sometimes this latter undergoes calcification. In the exudative form we find liquid effusions mainly of two kinds, sero-fibrinous (or even serous only) and purulent. In the non-purulent form, there is generally a fluid more or less opaque, greenish or milky, and containing floating masses and flakes of lymph. The quantity of serum is often very great, measuring several quarts. If the fluid be reabsorbed, as it may be, then adhesive changes go on, as described in the originally dry form.

In the purulent effusion there is great variety in the quality of the liquid: sometimes it is only a thin, turbid, purulent fluid, at other times it is a thick, soft, creamy pus. As regards quantity, the thinner fluids are usually copious, while the more inspissated are much less in amount. The fluid usually gravitates to the lower and back part of the abdomen. Many exceptions to this rule are observed, owing to adhesions, etc.

When purulent collections are long delayed in certain parts ulcerations of the peritoneum are apt to occur, with possibly perforations into hollow organs.

If an attack of purulent peritonitis does not prove rapidly fatal, a more chronic inflammation continues and leads to the formation of pouches and sacs which remain filled with pus. Fistulous openings may be found by which pus has discharged either into some of the hollow viscera or through the parietes. In the latter event the commonest situation is at the umbilicus.

Symptoms.—The onset of acute peritonitis is generally well marked, it being rare to meet with any prodromal symptoms. In very acute cases there may be an initial rigor, but this is unusual. Pain sets in at once. This is most commonly located in some particular part of the abdomen, but it rapidly spreads over a large area. It may be general from the outset. The fact of peritonitis being so often secondary to other intra-abdominal diseases causes its early symptoms to be frequently modified or masked by those already existing.

The degree of pain is most commonly great, and very often its intensity is extraordinary. It is variously described as hot, burning, boring, etc. From time to time it is increased by the spasmodic movements of the intestines. The abdomen is found very tender. In well-marked cases it is so tender that the slightest touch or the least attempt at movement of the body causes great suffering. In consequence of this, the position generally assumed is upon the back, with the knees drawn up so as to relax the muscles of the parietes.

Depression of the diaphragm is very limited, and the respiratory movements become shallow and wholly of the costal type. Full inspirations, coughing, and sneezing are carefully avoided. There is complete loss of appetite and great thirst. The tongue is furred, soon assuming a red and irritable appearance. It becomes very dry. A bitter, disagreeable taste is complained of.

The facial expression becomes singularly altered, giving a striking appearance to the physiognomy, which is of the highest diagnostic importance. The features become drawn and sunken, while the nose looks pointed and pinched. The eyeballs seem to fall back in their sockets. The expression is one of pain and anxiety. The voice becomes weak.

Vomiting is seldom absent. It may occur at once, or at any rate is likely to show itself early and is a prominent symptom. The vomited matters will be at first the ordinary contents of the stomach, then mucus with bile, and later matters which are largely composed of bile and present a grass-green color. In the later stages stercoraceous vomiting may set in.

The irritability of the stomach is often very great, for when the vomiting has lasted some time there may be instant rejection of everything that is taken, both solid and liquid. The act then comes to be more like constant eructation of gas and small quantities of fluid than actual retching. When this is the case, the patient is very apt to be annoyed by persistent hiccough. Thirst, more or less present at all times, becomes urgent as the vomiting continues, and frequently is most tormenting, impossible as it is to allay it, owing to the irritable condition of the stomach.

The abdomen tends to become distended to a greater or less extent. This tympanites may show itself very early, and depends, for a time at any rate, a good deal upon the flaccidity of the abdominal walls. The tension of the parietes becomes very perceptible to the examining hand, and is usually involuntarily increased upon palpation.

When the tympanites is very considerable, it is sometimes possible to observe the outline of certain of the folds of intestines, and to recognize in them the peristaltic twitchings accompanied by rumblings. This phenomenon, however, will not be met with in that remarkable fashion in which it is found in cases of obstruction or constriction of the intestines.

Gaseous hyperdistention of the abdomen may lead to much displacement of the diaphragm, crowding of the lungs, and pushing of the heart's apex a space or more above its normal situation.

Percussion, of course, yields a deep, resonant, tympanitic note, limited to the abdominal regions if the meteorism be moderate, and not extending much beyond the normal limits. The most constant condition of the bowels is constipation, moderate purgatives failing to act. To this rule there are exceptions, and it is even possible to have diarrhœa present, but this is very unusual.

The urine has the characters common to febrile urines. It is usually markedly diminished, and may even be suppressed. There may be frequent and even painful micturition at first, while retention is very apt to follow.

The temperature generally rises, perhaps to several degrees, marking considerable fever, and continues high (with fluctuations) perhaps till near, or up to, the end. To this general statement, however, there are many exceptions. There may be only very slight elevation of temperature, even in severe cases involving the serous membrane very extensively. Indeed, I have seen cases of fatal suppurative peritonitis running the greater part of their course with a temperature either normal or only fractionally above or below normal. Such observations sometimes come to have an important bearing upon the diagnosis, for it is a common impression that this serious disease, being inflammatory in its nature, necessarily produces some disturbance in the body temperature.

The pulse is very frequent, often reaching from 130 to 140 in the minute. It is a small, hard pulse, hence called "wiry." Before death it becomes extremely rapid and very weak. In exceptional cases the pulse in acute peritonitis does not present any special characters.

Effusion is probably always present, but quite frequently in such a small amount that its recognition is impossible. The liquid will follow the general law, being found in the most dependent parts of the abdomen, and presenting indications of mobility.

Consciousness generally remains clear, often painfully so, until the end approaches, but delirium may show itself in the later stages. In a number of cases delirium is probably due to the narcotics employed in the treatment.

As regards the probable result, it must be said that acute diffuse peritonitis is always severe and often dangerous. The least dangerous is the form with plastic effusion; the most so, that presenting an abundant purulent fluid.

Physical Signs.—These are of much importance, and therefore demand special notice.

Fulness of the abdomen will not be observed at first, but will be recognized as soon as flatus has had time to collect. It is seldom absent, but in persons with strong muscles this sign may be almost entirely wanting. The abdomen does not rise and fall during the respiratory movements. The peristalsis of the intestines is sometimes visible. By palpation the belly is felt to be smooth and regular. The abdominal muscles become tense under the examining hand; rarely a friction-fremitus can be felt.

On percussion a full tympanitic note is elicited, perhaps uniform over the abdomen or modified in tone over certain areas. The normal dulness of the liver and spleen may be greatly diminished or annihilated. If there be a sufficient quantity of fluid in the peritoneum, a dull note will be heard on percussing over the dependent parts.

Auscultation is of very little service, only the sounds produced by the movement of fluids in the stomach and bowels being heard.

Physical examination of the thoracic organs is likely to reveal diminished aëration of the bases of the lungs and displacement of the heart upward.

Prognosis.—The disease usually runs a rapid course, and the mortality is very large. The result depends, to a great extent, on the exciting causes, and, considering the great variety of the latter, it is difficult to use statistics to any useful purpose.

In fatal cases death takes place usually within seven days. Subacute cases may run a course of three weeks. The most acute and the most lethal forms are those arising from perforation, and those which are the result of septic infection. Plastic peritonitis is quite commonly recovered from, and sero-fibrinous not infrequently. When there has been considerable liquid effusion, a chronic stage may be entered upon. Collections of fluid may be enclosed or encapsulated by adhesions and become inspissated, or they may become purulent and the contents escape by some kind of perforation and the establishment of a fistula. These conditions may set up septicæmia, or they may prove dangerous through interfering with nutrition.

It will then be seen that in any case where recovery does not set in quickly the prognosis must be sufficiently guarded, having reference to the not rare possibilities just mentioned.

Diagnosis.—It is not difficult to recognize the onset of this disease. The association of most or all of the symptoms above detailed usually has an emphatic significance. Acute pain in the belly, vomiting, constipation, meteorism, quick pulse, elevation of temperature, collapse. The subsequent demonstration of intra-peritoneal fluid is very important. There may be doubt at first concerning the pain being possibly neuralgic. The chief distinction here lies in the fact that the peritoneal pain is specially aggravated by even slight pressure or movement.

A condition which is not infrequently confounded with peritonitis is that which results from obstruction of the bowels. This, however, begins with colicky pains, then vomiting, which is likely to become stercoraceous; the pain is referred to some special region; the temperature is not above the normal, while in peritonitis pain, which is apt to become diffused, is accompanied with great tenderness and rigidity of the abdominal walls, and probably some elevation of temperature and a hard, wiry pulse.

A *suppurative cellulitis* of the abdominal walls may at first simulate peritonitis. Careful inquiry, however, shows absence of the vomiting, wiry pulse, and constitutional depression of the latter; while soon redness and the projection of the part affected makes its real nature clear.

Hysteria, the great simulator, may make it difficult at once to decide what we have to deal with. In hysteria complaint is made of the slightest possible pressure by the patient, while if the attention be otherwise directed, even deep pressure will be borne without wincing. There is no disturbance of either the temperature or pulse in hysteria, usually.

Among other conditions which may resemble peritonitis may be mentioned excessive tympanites, as in typhoid and other febrile conditions, acute pleurisy, and pneumonia, when the pain is referred to the upper part of the abdomen.

It is often very difficult, often impossible, to diagnosticate the pre-existing condition which has been the cause of an attack of acute peritonitis. To do this it will be necessary to scrutinize carefully the past history with reference to the functions of all the abdominal organs, estimating carefully the bearing of any derangements in these upon the case in point, the situation in which the peritonitis first localized itself. Pain may be very deceptive, as it may be far removed from the locality where the originating trouble existed.

Certain parts are specially liable to diseases, which set up neighboring peritonitis, *e.g.*, the structures in the right iliac fossa, and the uterus and its appendages. These must, therefore, be always specially borne in mind, as well as the frequent occurrence of trouble from various forms of hernia and ulcerative processes in the stomach and bowels.

Treatment.—The indications are to remove, if possible, the exciting cause; failing this, to relieve pain, lessen congestion, prevent effusion, and allay other urgent symptoms. With reference to depletion I believe that, where the invasion is sudden and sharp, in a person of any reasonable degree of vigor, the application of six to twelve leeches often subdues rapidly the distress, and influences the progress of the case for good. English and American writers continue to recommend the application of external heat (fomentations and hot poultices), while the Germans approve highly of the opposite method of treatment, viz., ice. It is claimed for the latter that, besides its constringing effect upon the vessels, it has also a tendency to restrain meteorism, by diminishing the temperature of the gases and thus reducing their bulk.

Opium is still the drug chiefly relied upon and almost universally employed. It relieves pain, arrests peristaltic action and the intestinal secretions, quiets the nervous system, and relieves vomiting and hiccough. It requires to be given in full doses, the actual amount being gauged by the severity of the pain, and other symptoms. It should be given in sufficient quantities to keep the patient comparatively comfortable. Now, the amount necessary to do this necessarily varies much in individual cases. It should be always remembered that there is a marked tolerance to this agent in this disease. This is probably owing, in the first place, to the severe pain, and secondly to the diminished absorption. It is the custom with some physicians to push opium in peritonitis to full narcotism; this I believe to be not only unnecessary, but actually injurious. All the good that can be accomplished by opium in this disease can be effected by doses just sufficient to arrest pain and limit the peristaltic movements. Its power for good depends entirely on the fact of its being able to bring about these effects, and anything more is certainly injurious. It is, however, important that the doses should be free enough to effect these purposes.

The bowels should not be disturbed by cathartics, or even by enemata, until all the active symptoms have entirely subsided. If the case progresses favorably the constipation will gradually disappear and natural evacuations will occur.

For the tympanites, lime-water, charcoal, etc., may be useful. If the distention becomes very considerable, one might, by the introduction of a long tube, relieve it somewhat. It is seldom, however, that this procedure is effectual. Puncture of the intestines by a fine trocar needle is recommended by some, but it cannot be considered free from danger. Persistent vomiting is to be combated by small bits of ice, or by iced champagne in small quantities.

As to the feeding of the patient, it is important that at first little or no food should be given, and for some days it should be limited to teaspoonfuls of milk with an equal quantity of lime-water or rice-water.

When there are symptoms of failure of the circulation, then, and then only, should food be given freely, and then even only in small quantities at a time.

There is no doubt that in the near future much can be hoped from surgical interference, especially in those desperate cases of peritonitis from perforation. Up to the present the cases are few—too few to lead to any dogmatic statement either for or against the procedure.

Varieties.—Some of the special forms of diffuse peritonitis necessitate a separate description.

Peritonitis from Perforation.—This will include all cases in which the inflammation originates from a rupture into the peritoneum from ulceration or by traumatism. This class forms a very considerable proportion of all cases of diffuse peritonitis.

In many of these cases special symptoms of a perforative peritonitis are not present. The latter are only fully developed when gas has escaped from an opening in some one of the hollow viscera. By far the most frequent cause of perforation into the abdominal cavity is an ulceration, through the walls, of some point in the stomach or bowels. The destructive process passes through one coat after another, and finally the serous membrane itself gives way and the road is open for the escape of gases and fluids. When the ulcerative process already exists, the final step of bursting through the thin peritoneal covering may be brought about by the advance of the ulcerative process, or it may be precipitated by some condition causing increased tension, as flatulent distention, fæcal accumulation, etc., or by sudden strong peristaltic action, or lastly by traumatism, such as concussion or a blow. The occurrence of perforation may be preceded by symptoms indicative of gastric or intestinal ulceration, typhoid fever, typhlitis, or appendicitis, etc.; but, on the other hand, it may occur quite suddenly without any such clinical history. It sometimes happens (as in rupture of the pleura preceding pneumothorax) that the patient describes a sharp, located pain at the moment of the accident. This must be from the actual tear in the serous membrane, for it is felt instantaneously and thus precedes the occurrence of the inflammation. In a well-marked case the pain then extends with great rapidity over the whole abdomen, and soon very decided evidences of collapse are observed—face pinched and

haggard, extremities cold, and the pulse very rapid and feeble. The case runs a most rapid course with all the symptoms above detailed. Perforation may, however, be latent, owing to the previous existence of peritonitis, or to the symptoms being masked by those of typhoid fever already present. If extensive or universal adhesions be present, a perforation may not be accompanied by any definite symptoms.

With reference to the *diagnosis* of perforation, the most important points are the previous history, the suddenness of the onset, and proof that the existing tympanites arises from distention of the peritoneal cavity and not of the intestines. The abdomen is generally much and uniformly distended, the epigastric region, however, inclining to be the most prominent. The liver is displaced upward and so much backward that loud, deep resonance replaces the normal dulness. The flat note of the liver can only be found in the axillary region. The splenic dulness is likewise annihilated. A dull note can usually be elicited in the dependent parts of the abdomen.

It has been asserted that gaseous distention of the peritoneal cavity may occur from the development of fluids in this cavity. From recorded observations, it is probably impossible to deny this possibility; but it is quite certain that the occurrence is of such rarity, that the value of the physical signs of gas within the peritoneal cavity is not at all diminished.

In perforative peritonitis vomiting is generally a very prominent symptom, and constipation is obstinate.

The course of the disease is rapid. Death commonly ensues from collapse, in a period of from a few hours to two days; very seldom longer. Traube claims to have proved that recovery may ensue.

As regards the *treatment* of perforative peritonitis, the same means are called for as in acute diffuse peritonitis from other causes. Owing to the greatness of the pain opium is urgently called for. To meet the collapse we must administer ethereal and alcoholic stimulants freely. The tympanites may be so great as to threaten life, and when this is the case puncture must be performed to give relief.

Infantile Peritonitis.—Acute inflammation of the peritoneum cannot be considered a common affection among young infants. The diagnosis must be arrived at by examination of the facial expression and observation of the peculiar cry. A child with peritonitis will not cry loudly, owing to the pain thus induced, but will almost continually show signs of being in distress; pressure on the abdomen markedly aggravates this, and the belly very soon becomes strikingly tumid and hard. Vomiting is less common and less frequent than in adults. There may be considerable fever. This is a very fatal disease in young children. The affections with which it may be confounded are chiefly simple colic, gastro-enteritis, invagination, and in the latter stages, ascites.

Latent Peritonitis.—The characteristic symptoms of peritonitis may sometimes be wanting, and the case pass on to an advanced stage in an obscure fashion. We thus find a form called *latent* peritonitis sometimes spoken of and described. This latency of a disease whose onset and course are generally marked by such striking symptoms, is sometimes accounted for by the previous condition of the peritoneum. If a patient be in a weak or typhoid state, the occurrence of a peritonitis may readily enough escape observation. But even here, if, with a dulled intellect, pain is not complained of, still pressure upon the abdomen will generally elicit some indications of existing tenderness. In a certain number of latent cases, however, this explanation does not hold, and, indeed, none which is satisfactory can be given.

Circumscribed or Local Peritonitis (Acute and Chronic).—Attacks of this kind are rather common, and arise from a great variety of causes. They are usually not in any way dangerous, *per se*; but, later on, serious derangements, it may be, are induced by fibrinous adhesions, and constitutional disease as well as local disorder may result from the presence of pent-up effusions.

The symptoms of a local peritonitis are to a certain extent similar to those already described, the chief differences being that the local indications remain confined to certain areas, and that the constitutional symptoms are largely wanting. There is early pain in some well defined locality, at first, tenderness is felt only on deep pressure, but probably after a short time it is more readily brought out. Pain subsides as the inflammation subsides. Vomiting may be present, but is not urgent, and meteorism is rather uncommon. The temperature may run sharply up, but soon falls again, or it may be scarcely influenced at all. If, however, pus forms and remains encysted, very irregular fluctuations of the temperature may be looked for.

If a collection of fluid form, we may observe a localized fulness with a sense of resistance, or a distinct tumor which is dull on percussion. Such conditions are, however, not easily made out, the muscular contraction of the parietes often interfering with the necessary palpation, or the deep seat and imperfect definition of the collection preventing it from being recognized. Under these circumstances perforations in various directions are not uncommon, and cause a variety of complicated results: intercommunications between organs; escape of gas into an abscess cavity; an opening into the lumen of the intestines permitting matter to escape; or a direct opening through the peritoneum. The filling up of a pus-sac with gas through such a perforation is sometimes recognizable by the change in the physical signs (notably those obtained by percussion). A case of this kind came under my observation, where perforation occurred and an enormous collection of gas found its way above the liver, insinuating itself beneath the diaphragm, and so displacing the latter as to give rise to physical signs closely simulating those of pneumothorax.

Partial chronic peritonitis is, on the contrary, for the most part latent. It results in the slow formation of bands and adhesions, during the development of which no symptoms at all may be produced.

The reason for the absence of symptoms is the chronicity of the inflammation; for, probably, even a trifling hyperæmia of the peritoneum will be accompanied by pain if it be developed acutely.

II. Chronic Peritonitis.

Chronic Diffuse Peritonitis.—A peritonitis which persists after a chronic fashion is rare, except when due to tuberculosis. Still there is sufficient evidence that a general peritonitis of non-specific origin may be met with. The most frequent form consists in the development, first, of an acute attack, absorption and resolution failing to occur. If an acute inflammation leave behind it an encysted collection of fluid, this may cause a low form of inflammation to spread from it until the whole peritoneum is involved.

The symptoms thus come to be partly due to existing effusion, and partly due to extension of the inflammation. Tenderness on deep pressure remains, and colicky pains are often excited on taking food. Vomiting may occur, but it is more frequent to find uneasiness after taking food.

Two opposite conditions may thus be met with in these cases, viz., a normal-looking or flattened belly, or one greatly distended; the difference depending in the first case on absorption of the previous effusion, and in the other on very considerable additions to the same by fresh exudations. The bowels are irregular, constipation alternating with diarrhœa; gastric and intestinal digestion are interfered with. The pulse remains quiet, and the temperature is fluctuating, sometimes remaining steadily normal for a time, and then again, for another period, being elevated every afternoon and evening.

Encysted collections may be felt as irregular, firm tumors within the abdomen, and over these the percussion note will be more or less dull. The general health during this prolonged illness suffers much; in the end a state of great emaciation and anæmia being produced. Even in these unpromising cases recovery may ensue, for the matter may find a road by which it can discharge itself; but when fistulæ form, the patient, much more commonly, becomes still more wasted and hectic, from the continual

drain. The prognosis is therefore bad, most of these persons dying marasmic. Recovery can be looked for either by absorption of the fluid and caseation of what remains, or by a free discharge of the pus in some safe direction.

Sometimes chronic peritonitis arises during, and apparently as a direct result of, ascites, from various causes. The inflammation is of a very low type, and the symptoms may be correspondingly ill-marked; so much so, that the existence of this complication often escapes observation. The only complaints may be of occasional vomiting and some indefinite tenderness in the belly.

In a patient suffering from ascites, such symptoms are extremely likely to present themselves without any peritonitis.

A primarily chronic peritonitis advancing without any symptoms, until copious effusion has occurred, is described by some authors. This latent chronic general peritonitis corresponds to the "idiopathic dropsy" of older writers. Its existence is disbelieved by many; at any rate, it is a very rare occurrence.

Tubercular Peritonitis.—The slightest form in which we meet with tuberculous disease in the peritoneum—a form which is of no clinical import—consists in the development of localized granulations upon the serous coverings of tuberculous ulcers of the intestines.

It also is met with, in the bodies of those dying from general tuberculosis, in the form of fine miliary tubercles scattered perhaps uniformly here and there over the surface of the peritoneum.

Tuberculosis of the peritoneum may, however, occur either independently or, at any rate, with such a degree of independence as to play the most important part in the diseased processes. It is often secondary to pulmonary phthisis, or is traceable to some pre-existing caseous glands situated in the abdomen or elsewhere. It is sometimes seen as the result of tuberculosis of the kidneys and urinary passages. Very exceptionally it appears to be primary. It is rarely met with in individuals under four years of age, being mostly seen in young adults.

As the morbid process is essentially a chronic inflammation, the adhesions are numerous and strong. Usually the effusion is scanty, and not infrequently bloody.

Unless we have distinct evidence of a previous tuberculosis elsewhere, the recognition of tubercular peritonitis is difficult, often impossible. *George Ross.*

PERIWINKLE. Two species of *Vinca* are known by this name. They are low, evergreen shrubs, with straggling or creeping stems, and handsome lilac-colored (sometimes white) flowers. Both are official in France, but are about obsolete as medicines. *V. major* Linn. (*Pervenche grande*, Codex Med.), is a foot or two high, with ovate, hairy-edged leaves. *V. minor* (*Pervenche petite*, Codex Med.) has creeping stems and smaller, entirely smooth leaves. Both are cultivated for ornament in this country, especially the last, which is an old favorite for shady spots.

The leaves are used. They have been considered of benefit in menorrhagia, and in drying the milk of nursing women. Their value is probably infinitesimal.

Allied Plants.—See Hemp, Canadian.

W. P. Bolles.

PEROSMIC ACID, POISONING BY. Perosmic acid, commonly called osmic acid, is, strictly speaking, the tetroxide (peroxide) of osmium. It forms colorless, acicular crystals, which sublime even at ordinary temperatures. It is easily fusible to a colorless liquid, which boils at 100° C. (212° F.), yielding a very irritating and deleterious vapor, whose odor resembles somewhat that of chlorine. It is readily soluble in water, forming a neutral solution, and possesses a sharp, burning taste.

The effects of osmic acid on man, when administered by the mouth, are unknown. Experiments on animals show that it is a poison in doses of a few grains by whatever channel it may be introduced into the system (Gmelin, Barnell). The acid has been employed to some extent in the treatment of peripheral neuralgias and tumors. For this purpose a one per cent. solution in water, or preferably water and glycerine, is injected subcutaneously in doses of five to ten drops daily. Usually no ill-effects, either local or constitutional, have followed this method of application. In a few cases, however, the injection is said to have caused pain and swelling, and even sanguineous bullæ and boils (Leichtenstern), at the point of puncture.

The vapor of osmic acid is exceedingly irritating to the mucous membrane of the eyes, nose, larynx, and lungs. In small quantities its action is not unlike that of other irritating vapors, being manifested by lachrymation, irritation of the nose and larynx, severe coughing, and difficulty in breathing. In larger quantity it may, like any other irritant gas or vapor, cause death. It acts most violently on the eyes, causing severe pain and inflammation of the conjunctiva. Vision may be permanently impaired in consequence of the reduction of the oxide and the deposition of metallic osmium. Osmic acid also appears to act violently on the skin, causing a painful eruption. Barnell, who made over two hundred experiments on animals, and was in consequence more or less exposed to the action of the acid during a considerable period, experienced, as a result of his prolonged exposure, a feeling of weight and a sensation of cold in the back extending to the loins, pain in the region of the groin and in the testicles, swelling of the inguinal glands, loss of appetite, and malaise. These symptoms slowly disappeared when the exposure was discontinued ("Schmidt's Jährbucher der gesammten Medicin," 1850, 68, p. 371).

Raymond (*Le Progrès Médical*, June 27, 1874) relates a case of osmic acid poisoning, in which the prominent symptoms were pains in the eyes, an eruption on the surface of the forearm, on the face, and on both sides of the hands, indigestion, diarrhœa, and violent headache. Pneumonia soon supervened and the patient finally died. The only pathological appearance which could fairly be attributed to osmic acid was a considerable amount of inflammatory action along the greater curvature of the stomach. On chemical analysis of the various organs no trace of osmium could be detected. Raymond, however, concluded that the case was one of unquestionable poisoning by osmic acid.

In the present state of our knowledge, treatment must be chiefly symptomatic. As an antidote to the effects of osmic acid, Claus recommends the cautious inhalation of sulphuretted hydrogen. *William B. Hills.*

PERRY SPRINGS. *Location and Post-office*, Perry Springs, Pike County, Ill.

Access.—By the Quincy Branch of the Toledo, Wabash & Western Railway, now called the Wabash, St. Louis & Pacific.

Analysis (H. Engelmann, Md.).—One pint contains:

	No. 1. Middle or Magnesium Spring.	No. 2. Upper or Sulphur Spring.	No. 3. Lower or Iron Spring.
	Grains.	Grains.	Grains.
Carbonate of potassa	0.199	0.181	0.157
Carbonate of magnesia	1.260	1.097	0.777
Carbonate of iron	0.051	0.040	0.025
Carbonate of lime	1.380	1.715	1.708
Sulphate of soda	0.055	0.137	0.173
Silicate of potassa and soda	0.330	0.285	0.431
Silicate of soda	0.015	0.048	0.072
Silicate of alumina	.....	.....	0.034
Total	3.290	3.503	3.377

Therapeutic Properties.—These are mild alkaline waters.

These springs are situated in the western part of Illinois, about thirty miles west of Jacksonville, in a beautifully wooded valley on the bank of a small stream. They issue from a limestone formation, and have a flow of from one to two gallons each per minute. *G. B. F.*

PERSPIRATION, PHYSIOLOGY OF. The secretion of sweat is produced by the sweat-glands, which in man are distributed over the entire cutaneous surface. In animals, with the exception perhaps of the horse, the sweat-glands are less numerous and are limited to certain parts.

Some monkeys, as far as they have been examined, perspire on the hands, feet, and face. Cats and dogs have sweat-glands only on the soles of the feet and on the end of the nose; and the familiar rodents (rabbit and mouse) have none at all.

The secretion of sweat is not a continuous one. According to circumstances the condition of the glands may vary between inactivity and intense action. Under physiological conditions the amount of perspiration is determined principally by the temperature of the surrounding air. Cold stops the activity of the sweat-glands; heat increases it. Muscular exercise likewise causes perspiration, most abundantly in the cutaneous region over the active muscles. The amount of perspiration further depends upon the quantity of fluid absorbed from the alimentary canal into the blood. Any excess of water in the blood is excreted rapidly by the skin and kidneys.

Of these two sets of glands the excitation of either one reduces for the time the activity of the other. The skin, however, governs the activity of the kidneys more than the kidneys that of the skin. If the external temperature be high, and, especially if exercise be taken, the skin excretes the greater amount of fluids previously drank, relieving the kidneys of part of their work; while, when these conditions do not exist, the kidneys have the principal share in the removal of water from the body.

Perspiration can also be started by various strong emotions. While the normal perspiration is accompanied by increased vascularity, and consequently warmth of the skin, a cold sweat may occur in consequence of depressed mental condition, nausea, or collapse. Under these circumstances the skin is cold and clammy, and its blood-vessels are relatively empty.

The perspiration is sensible only when the sweat accumulates in drops upon the skin. Whenever the sweat can evaporate as fast as it is secreted, it is referred to as insensible perspiration. The rate of evaporation of the sweat depends upon the dryness and temperature of the surrounding air, and to a minor extent upon the temperature of the skin. A given volume of air (or the same actual space devoid of air) can hold only a certain amount of aqueous vapor according to the temperature. The following table gives the weight in grammes of aqueous vapor, which one cubic metre of air can hold at different temperatures (centigrade scale):

At −20°	1.064 grammes.	At +10°	9.372 grammes.
At −10°	2.500 "	At 25°	17.164 "
At 0°	4.874 "	At +30°	30.359 "

Air containing all the vapor which it can hold at a given temperature is said to be saturated with moisture. Whenever this condition occurs, which is the case only during fogs, no evaporation is possible (unless the air be cooler than the skin), and all the perspiration becomes sensible. On the other hand, the evaporation will increase with the relative dryness of the atmosphere, and still more so with a rise of the atmospheric temperature, on account of the augmented capacity of the hot air for aqueous vapor. Since the slow diffusion of the vapor in still air as it arises from the skin causes saturation of the layer of air next to the cutaneous surface, the evaporation is increased by any movement of the air. With a given degree of atmospheric dryness, the rate of evaporation from the skin depends on the absolute temperature of the skin, and increases with the latter. Under normal conditions of perspiration, however, the temperature of the skin is not subject to extensive fluctuations, for when the skin is cold the sweat is not secreted ordinarily.

It is probable that the principal, if not the only, utility of the perspiratory secretion consists in the cooling produced by the evaporation of sweat. The chemical analysis of the fluid has not proven it to be a secretion ridding the body of harmful products, and such an hypothesis is further rendered unlikely by the limited development of sweat-glands in other mammals, and the relative, or even absolute, inactivity of the human sweat-glands in cold weather. The perspiratory function is evidently one of the means of heat dissipation of the human body. The mere secretion of sweat does not affect the temperature of the skin, but the evaporation of the fluid deprives the body of the excess of heat produced. It has been calculated that about three-fourths of the total heat produced by the chemical energy of the body is dissipated through the skin, partly by radiation, partly by the transformation of fluid sweat into aqueous vapor. The latter is the more important cause of the loss of heat, for radiation must practically cease when the temperature of the air is the same as that of the skin, while evaporation is checked only by complete saturation of the air with aqueous vapor. In ordinary weather the air contains rarely more than about sixty per cent. to eighty per cent. of its capacity of aqueous vapor, while its absolute capacity rises, of course, with the temperature. Even when the air is saturated with moisture, evaporation can still occur if the skin be warmer than the air, and all the more so when the air is in motion. These considerations explain why the skin can be comfortably cool in the hottest weather if the air is relatively dry, and especially if a wind prevails; while a stagnant atmosphere laden with moisture exerts its well-known depressing effect upon the body, and does not allow the skin to cool off in spite of violent perspiration. Animals that do not sweat regulate their bodily temperature by evaporation of water from the surface of the lungs, and increase, in hot weather, the volume of air entering the lungs by panting.

The daily amount of perspiration is probably in the vicinity of one litre (two pints) in average weather. This quantity represents about the deficiency of water not passed off through the kidneys and lungs, as compared with the total amount ingested in the form of drinks and solid food. Estimates which have been made of the weight of the sweat by weighing absorbent clothes applied to the skin, or placing the body (or a part of it) into air-tight receptacles, have, of course, yielded variable results according to the conditions of the experiments. In extreme warmth of the surrounding air the body can lose more than one kilogramme (about two pints) of sweat per hour.

Nervous Mechanism of Perspiration.—The sweat-glands act normally only under the influence of a special set of nerves—the perspiratory nerves. These nerves control the secretion in as precise a manner as the motor nerves govern the muscles. Their influence can be demonstrated by stimulating the nerve-trunks supplying the paws of a dog—or, still better, of a kitten—for instance, the sciatic nerve for the hind leg, whereupon drops of sweat appear promptly on the hairless skin. That this nerve influence is independent of circulatory changes can be shown by repeating the experiment successfully after amputation of the leg.

In the course of some twenty minutes, however, after stoppage of the circulation the sweat-glands lose their excitability. The excitability of the glands depends further upon the temperature of the skin. Chilling the leg paralyzes the sweat-glands temporarily, while their response to nerve stimulation increases with the temperature up to a point a few degrees beyond the bodily warmth. Immersion of the leg in hot water of about 50° C. (122° F.) will again paralyze the glands for a time.

Activity of the sweat-glands, like muscular contraction, is accompanied by electric changes. By means of a sensitive galvanometer and unpolarizable electrodes, a current passing from the surface inwardly can be detected whenever the perspiratory nerves are stimulated, even when the stimulation is so slight as to cause no visible secretion.

Except under the influence of certain poisons, the sweat-glands do not act independently of their nerves. Destruction of the perspiratory nerves causes permanent inactivity of the corresponding glands. These nerves, like

centrifugal nerve-fibres in general, undergo degeneration when severed from the spinal cord, and lose their irritability in the course of about five days. Their mode of termination in the sweat-glands has not yet been discovered.

The course of the perspiratory nerves can be followed by stimulating the nerve-centres, either directly, by asphyxia, or in a reflex manner, by placing the animal in a warm box. Under these circumstances free perspiration ensues, except in the part the nerves of which have been cut. It can thus be demonstrated that there exist centres for the sweat-nerves in the spinal cord which are presumably subordinate to a general dominating centre in the medula oblongata. The nerve-fibres going to the sweat-glands are contained in the trunks of the peripheral nerves supplying the corresponding regions of skin. But they enter these trunks only to a minor and variable extent through the corresponding anterior spinal roots, while the bulk of the perspiratory fibres follow a circuitous route through the sympathetic system. They leave the spinal cord with the anterior roots of the last three or four dorsal, and four upper lumbar, nerves, join the abdominal sympathetic, and thence pass into the brachial plexus for the fore-leg, and into the ischiatic plexus for the posterior extremity. The perspiratory nerves of the face are probably to be found within the sheath of the fifth nerve and its branches, and not in the trunk of the facial nerve. This, at least, is their distribution in the horse, and probably also in man, judging from the negative results, as far as perspiration is concerned, when the facial nerve is destroyed by disease.

It has been suggested that there may exist inhibitory nerves which can check the secretion of sweat, because section of the sympathetic nerve of the neck in the horse is apt to be followed by perspiration upon the same side of the face. It is more likely, however, that the secretion thus produced is the result of the increased vascularity, and consequently of augmented warmth of the skin from vaso-motor paralysis.

The sweat-centres are stimulated in a reflex manner whenever the skin is warmed. The reflex origin of the secretion thus produced is proven by its cessation when the corresponding nerves are cut. The centres may be directly stimulated by the venosity of the blood during asphyxia, when the skin becomes bathed in perspiration. The centres may also be stimulated by various poisons, especially pilocarpine, which agent causes copious sweating both by throwing the nerve-centres into activity, and by augmenting the excitability of the glands. Paralysis of the sweat-glands, on the other hand, can be obtained by the action of atropine. *H. Gradle.*

PESSARIES. As we understand them to-day, pessaries are certain mechanical supports of various construction, which are used to correct displacements of the uterus, bladder, or vagina. In ancient times they were so medicated as not only to prevent displacement of these organs, but also to relieve pain and correct offensive discharges. They were then made of pledgets of wool or of hardened ointments, medicated, much or little, as occasion might seem to require. In the days of Hippocrates such pessaries of stiffened or hardened ointments, or woollen pledgets, were medicated with stimulants, cantharides, camphor or myrrh, colocynth, etc., to produce abortion, relieve amenorrhœa, etc. Or they were medicated with astringents to check excessive hæmorrhage, profuse vaginal leucorrhœa, or other discharges. There can be little doubt but that much good was accomplished by such treatment, and to-day we are coming back to a similar course of action in some of our cases. We use anodyne or antiseptic cocoa-butter suppositories for the vagina, and the use of cotton tampons medicated in various ways is a quite universal practice with the majority of gynecologists. We employ different medicaments dissolved in glycerine, and thus meet all indications which may present themselves, by using some one of the different solutions to saturate the cotton pads.

At the present time we not only use occasionally the medicated hardened ointments and cotton pledgets, but also a great variety of mechanical appliances constructed especially for the purpose of keeping the displaced or distorted uterus, or the prolapsed vagina, in proper position.

There are now, and always have been, earnest advocates of these pessaries, no less than violent opponents of any mechanical aid. Such opposition will undoubtedly continue. But when we remember that there are educated men who are conscientiously opposed to vaccination, and others to the use of the knife in cancer of the breast, we cannot expect, and we need not try, to make all physicians believe in the advantages of vaginal pessaries.

There is a happy, golden mean between the too earnest advocate and the violent opponent of the use of the pessary, and here the judicious physician will find himself standing, after he has given a few really good instruments an honest trial. He will learn that pessaries, of whatever character, are often the source of great comfort to a patient, but are as certainly capable of doing much harm when too large, when allowed to remain *in situ* too long, or when they are inserted while a peri-uterine inflammation exists.

As a result of my own experience, which has been extensive and practical, I have come to consider a pessary a very great boon to many suffering women.

Some pessaries I do not introduce as frequently as formerly, because I have found, from long experience, that many *recent* displacements and flexions can be cured by the intelligent use of cotton tampons, medicated poultices, or medicated vaginal suppositories. And this treatment will be required but a short time to effect a cure. Nevertheless, I am persuaded that there are many women who can be more surely relieved and more quickly cured by wearing a vaginal pessary than by any other known means.

I do not propose to describe all the different pessaries in the market, for their number is simply surprising. I wish to recommend those which I know to be safe, simple, and the most useful, those which have really great merit.

Formerly we were accustomed to have many of our pessaries made of copper wire covered with soft rubber, or of block tin. In each case the pessary was fitted to the size and shape of the vagina and the displacement of the uterus. To-day, however, every physician should have several different sizes of each variety of instruments made of hard rubber, and by heating and shaping them, and covering some parts with rubber gauze, he can meet almost every indication. The superiority of hard rubber over any other material for the manufacture of pessaries is very apparent. It is light, strong, and easily moulded when properly heated, can be readily cleaned, and is quite inexpensive.

Pessaries may be used with advantage, if they are a comfort to the patient, even though their *modus operandi* in the relief of the pain may be very imperfectly understood. I doubt if many really useful instruments have ever been devised except by those who are constantly using pessaries. Theories do not answer; actual trial only can be depended upon for a judicious opinion respecting the merits or demerits of a certain pessary. The physician whose only experience in the use of pessaries is in the removal of those which have been inserted by another physician, and which have remained *in situ* much longer than the most reckless of gynecologists would advise or wish, has no qualification whatever to judge of the advantages of a well-adjusted pessary. The statement of one intelligent patient with a judicious mind, that she is decidedly more comfortable with than without a pessary, is infinitely more valuable than any theorizing by physicians who have had no opportunity to witness other than the ill effects of defective, badly adjusted, or too long retained pessaries. One of my patients, a very intelligent woman, graphically described her sensations of the comfort afforded by a suitable pessary in saying that "I felt twenty years older the day after the pessary was removed; I must have it replaced at once, for I cannot do without anything which adds so much to my bodily comfort." For myself, I am thor-

oughly convinced that there are a few among the multitude of pessaries in the market that are really valuable, and it will be my purpose to describe these few instruments, and to explain as far as possible the methods of their action, the cases in which they are useful, and the manner of their introduction and removal. I think I can safely advise the younger members of the profession against the folly of trying to make a new instrument for every patient that may seem to require a pessary.

It will be better to try some one of the many instruments recommended by physicians in a large gynecological practice. So much valuable time has been wasted in inventions, and so much money spent in manufacturing pessaries which are useless or absolutely bad, that it is well for young physicians to know that the ground has been thoroughly covered by many excellent men. And it is quite certain that nothing very useful will be devised by one who has not had considerable experience in treating displacements and distortions of the uterus. It is quite instructive to many of us, when looking over the instruments in any well-stocked shop, to learn that only those which have been invented by practical gynecologists are selling well. This is not due to the name which a given pessary may bear, but in a great measure to the fact that we are all ready to buy pessaries which seem to do good in the hands of our neighbors. Only a few of the vast number in the collection have proved effectual in relieving the discomfort of our patients. It is a marked example of the "survival of the fittest."

The manner in which a displaced uterus is kept in a normal position by a pessary, varies very much according to the character of the pessary used, and the mechanical principle involved. This must appear perfectly plain to any intelligent physician who watches the gradual expulsion of different pessaries from the vagina while the patient lies on her back upon the table before him. Or when, as he sits in a chair, the patient stands before him with one foot on the floor, and the other raised six inches and resting on some support, while he places an index-finger in the vagina and the patient is requested to bear down. Such a demonstration teaches very positively that a globe, a Gehrung, as well as several other pessaries, hold the uterus in nearly a normal position by preventing the prolapsus of the anterior wall of the vagina. And thus it is seen at once that a pessary supports and holds the uterus *in situ*, or, at least, aids in keeping it in its normal position, according to the different mechanical principles involved in each case, and which may be expected to act after insertion. We can, therefore, conveniently and judiciously divide them into several classes, and we shall find that this classification will aid us eminently in selecting a pessary for any given displacement or distortion. I would, therefore, desire to have these mechanical principles remembered by the physician who has a patient with a uterus which cannot be kept in place by the one or two instruments which may be at his command. I think we can at once understand that a stem pessary (Fig. 2864) resting in a cup supports a prolapsed uterus, or straightens the distorted organ, in a very different manner from a common Albert Smith pessary (Fig. 2849). And so, too, a Zwenck pessary (Fig. 2863) prevents procidentia uteri, but in an entirely different manner from that by which a Thomas hinge-cup pessary (Fig. 2855) will accomplish the same object. Not to understand some of these mechanical laws which should govern us in the selection of suitable instruments, will render us liable to grave mistakes, and will sometimes cause our patients much misery, and often extreme suffering. I would, therefore, arrange the pessaries which we are most accustomed to use at the present time under these several heads:

1. *Wedge-shaped, Lever Pessary.*—This pessary tightens the vagina at the posterior fornix, where the posterior or wide end of the pessary rests, pressing up against Douglas pouch. In rare instances, when the cervix is not drawn upward and backward by this tightening of the vagina at the posterior fornix, because of its great elasticity at this part, or when the vagina is subinvoluted, this pessary will be easily forced upward until it exercises a direct force upon the uterus near the junction of the body with the cervix, and by such direct force will raise a retroverted uterus into nearly its normal position.

Under this head comes the Albert Smith retroversion pessary (see Fig. 2849). This instrument fully deserves the almost universal favor it is receiving. Being wedge-shaped laterally, and curved in the opposite direction, like an imperfect or irregular letter **S**, it is retained in position by two forces, the wedge and the lever. First, the contractility of the vagina acts upon the pessary *as a wedge*, and will allow it to vary its position half an inch or more with every sudden jar of the pelvis. Second, the *lever power* exercised by the roof of the vagina upon the small or acute angle, *i.e.*, the anterior portion of the pessary, whenever an effort is made to bear down and force it out, tends to raise and hold the posterior fornix in the normal position. If the support from below, or the fulcrum upon which the lowest portion of the pessary rests, is not destroyed, no amount of forcing or bearing down will be likely to expel the pessary from the vagina.

2. *The Ring Pessary* (Fig. 2848).—This instrument supports the uterus to a certain extent by stretching or tightening the vaginal tissue at its attachment to the cervix. It will be readily seen that if the cervix is partially fixed in the centre of this ring (Fig. 2848), the whole organ cannot tip forward, backward, or laterally so far as it otherwise would, because of this fixation of the cervix. The distention of the vagina at this locality not only steadies the cervix, but also, as many of these pessaries are so constructed, lifts the whole organ up from the floor of the vagina by an indirect action on the cervix, by reason of this same distention or tightening of the roof of the vagina. But the fact that it is made to fit the vagina thus closely, renders the use of a ring pessary much more hazardous than that of a well-adjusted, wedge-shaped instrument, which varies its position slightly with each step or movement of the patient.

Fig. 2848.

3. *The Anterior Support Pessary.*—These instruments are so constructed that, when properly adjusted, they prevent prolapsus of the anterior wall, or cystocele. They consequently assist in keeping the uterus in its normal position in that class of cases only in which the organ prolapses because it is dragged downward by the descending or prolapsing anterior wall. Under this class we find the Grailly-Hewitt anteversion pessary (Fig. 2859) and the Gehrung anteversion pessary (Fig. 2855). There are two or three pessaries, very useful indeed, which are constructed on this principle of supporting the anterior wall, and yet are expected to steady the cervix also, and are therefore made wedge-shaped, thus combining the principles involved in classes Nos. 1, 2, and 3. These pessaries are the Thomas hinge-cup pessary (Fig. 2855), the Skene anteversion (Fig. 2857), and the Hanks anteversion pessary (Fig. 2856). All of these different pessaries in this third class are expected to raise the roof of the vagina, and are kept *in situ* by the contraction of the vaginal outlet above the perineum.

These instruments are wedge-shaped like the Albert Smith pessary. They have the long and short arm of the lever like the Albert Smith. They raise the roof of the vagina like the ball or Gehrung pessary. Therefore it will be seen that they combine all the principles claimed separately for the three several classes.

4. *The External Support Pessary.*—This class includes those instruments which are kept *in situ* within the vagina by a stem, which is fastened in various ways outside of the body. Such are Cutter's (Fig. 2862), O'Leary's (Fig. 2860), Hornby's (Fig. 2861), as well as several designed by Dr. Thomas.

5. *The Lateral Wing Expansion Pessary.*—Pessaries of this class prevent procidentia uteri by completely occluding the ostium vaginæ. The Zwenck butterfly pessary (Fig. 2863) is a typical instrument of this class. It is kept *in situ* by the expansion of the lateral wings, which rest upon the soft parts of the vagina cushioning the

ischio-pubic rami, and consequently it resists any expulsive force which the patient may exert. It can be displaced and removed only by unscrewing the stem, thus closing the wings.

6. *The Stem Pessary* (Figs. 2864, 2865, and 2866).—This instrument acts like a splint by preventing distortion of the canal of the uterus. By being fixed on a cup or some other pessary in the vagina, it also prevents displacement of the uterus. Certain metals are sometimes selected in the construction of the stem, in order to effect a cure by means of galvanic action.

Thus we have six varieties of pessaries, which will include nearly all kinds now in general use, and by understanding the manner of action of each class we shall then better understand what instrument to select for any particular displacement or distortion.

To recapitulate, we have:

1. The wedge-shaped lever pessary.
2. The ring distention pessary.
3. The anterior support pessary.
4. The external support pessary.
5. The lateral expansion wing pessary.
6. The intra-uterine stem pessary.

We come now to the different pathological conditions which, for the time being, are more or less relieved by some form of mechanical support. There can be no question, with a wise physician who has had much experience in treating diseases peculiar to women, but that retroversion and anteversion of the uterus, the different flexions of that organ, together with prolapsus uteri in its various degrees, and prolapsus of the anterior wall of the vagina, are all attended with a disturbed circulation, and consequently impaired nutrition, as well as being the cause of more or less distress and pain from such congestion, mal-nutrition, and disturbed function.

We must remember that a judicious physician is expected to call to his aid those means which are the least objectionable, and which will quickly and surely relieve the distress, and help nature to restore the parts to a normal circulation, and to perform their normal function. I have no doubt at all that a well-selected pessary will do this in the vast majority of cases of simple retroversion, anteversion, flexion, or prolapse which are uncomplicated with inflammation. It will be my purpose to go over this list of pathological conditions, and to offer suggestions to the reader concerning the wise selection, gentle insertion, and timely removal of such instruments as are known to me to be useful in these various conditions.

In retroversion of the uterus we have the whole organ changed with relation to its position in the pelvis. It should always be remembered that versions and flexions do not mean the same thing. Some of our older textbooks are sadly confusing in this matter, when applying these terms to the changes of, and in, the uterus.

Version means change of place of the uterus, while flexion means distortion or bending of the organ itself.

Therefore, we may have a flexed organ retroverted or anteverted, as the case may be. In considering versions we must always bear in mind the normal *position* of the uterus in the pelvis, while in flexion we must always bear in mind the normal *shape* of the organ itself. In retroversion the fundus falls backward and downward, below and under the promontory of the sacrum, while the cervix is tilted upward and forward toward the neck of the bladder. The causes of such condition cannot be considered here further than for the sake of such knowledge as will help us in selecting suitable pessaries. Suffice it to say, if the natural ligamental and peritoneal supports of the uterus are not sufficiently strong to retain the organ in its normal position without some mechanical aid, that this mechanical aid should not be called upon until a fair trial of other and more simple means has been made. The general health should first be built up, if possible. The bowels should never be allowed to become constipated, but rather the reverse. The bladder should never be allowed to become excessively distended. The urine should be examined, and if it is ammoniacal, or if evidence of chronic cystitis exists, these conditions should be corrected.

Douches of hot water should be used frequently to reduce congestion. The patient should not be allowed to carry on any labor which would aggravate a retroversion, and she should not be allowed to sleep lying upon her back, but rather always upon her side or face; and in rising from the bed she should never get up from her back, but turn first to one side and help herself with her arm and hand, and thus prevent the forcing downward of all the organs in the true pelvis by the contraction of the rectus abdominis muscle. But when all such preliminary treatment has been carried out, and when the organ, after having been restored to a normal position by the finger, sound, or repository, again and again retroverts as soon as the patient lies on her back or walks and becomes fatigued, it is then certainly time to consider the advisability of some direct mechanical aid to assist nature and prevent this condition of displacement. I know of no pathological condition where a tampon of cotton or a properly selected pessary will do more good than in this same class of cases which is known by the name of retroversion of the uterus. In the treatment of all these cases I would first place the patient in Sims' position, or so-called knee-chest position, and with a Sims or some modification of a Sims speculum examine the uterus carefully. If it is found to be movable and there is no evidence of peri-uterine inflammation existing, either acute or chronic, I would thoroughly sponge or douche the parts with some hot antiseptic fluid. Then, the anterior lip being seized with a tenaculum and drawn toward the ostium vaginæ, the posterior fornix can readily be packed with suitably medicated glycerinized cotton pads, fitted under and around the cervix. This tampon will be exceedingly comfortable, and can be worn usually for twenty-four hours. When it is removed the uterus is often found much lighter than when it was applied, because of the improved venous circulation. The ligaments and peritoneum are also frequently much strengthened because of the twenty-four hours rest from the severe tension which existed while the organ was retroverted.

It will be found, therefore, in almost all recent cases, that no other treatment will be required unless to repeat the same process, and support the uterus in proper position in the same manner for another day or two—or until a cure is effected. This cotton tampon pessary can do no harm, and, if well applied as stated above, will always relieve and often cure a recent retroversion of the uterus. But when the foregoing rules have been faithfully carried out and the displacement still recurs, we must call to our aid some one of the many forms of retroversion pessaries.

The most useful retroversion pessary is the hard rubber, *wedge-shaped, lever pessary* which is here shown. It is

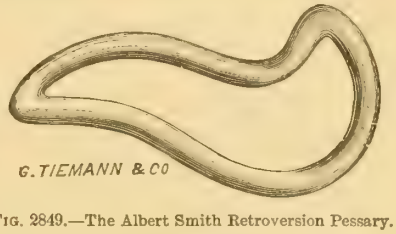

Fig. 2849.—The Albert Smith Retroversion Pessary.

called the Albert Smith retroversion pessary. This instrument (Fig. 2849) is made of hard rubber, of celluloid, or of various other materials, none of which is an improvement on the hard rubber. The wide end of the instrument is expected to pass behind the cervix and press against the vaginal tissue which constitutes the posterior fornix; while the anterior or narrow end is expected to lie under the neck of the bladder or urethra, as is seen in Fig. 2850.

It will retain the uterus in its proper position by steadying the cervix and preventing it from tilting forward, and also by keeping it raised above the floor of the vagina a full half-inch. It steadies the cervix because the posterior or wide end of the instrument is constantly keep-

ing the vaginal tissue, which is attached to the posterior lip, on the stretch

This tension of the vagina at the posterior fornix will not allow the cervix to move forward, consequently the fundus cannot fall backward and downward. The instrument, being wedge-shaped should not be held too tightly by the vagina, but should easily move upward and downward with every sudden motion of the body. It, therefore will seldom become imbedded in the vaginal tissue as does the elastic ring pessary, which remains constantly pressing outward on the vagina where it finds the least resistance. We can, therefore, safely trust ourselves to follow the teachings of every practical gynecologist of large experience who has written upon this subject, when he advises the use of some form of a pessary for a retroverted uterus. A well-adjusted pessary is safe and of great comfort to the patient, and in many cases the wearing of an Albert Smith pessary has effected a complete cure of retroversion. The only danger, which is so great as to be of the utmost importance to avoid, is the introduction of a pessary when there is an acute or even a chronic peri-uterine inflammation present. Pessaries will do no good, and will generally do much harm, if applied at such a time, by lighting up a more serious inflammation. Another danger to avoid is the use of too large a pessary, or of one that will become incarcerated, as it were, in the vagina.

Fig. 2850.—The Albert Smith Retroversion Pessary in Position.

In other words, we must always be sure that there is no peri-uterine inflammation, and that the instrument is easily movable in the vagina.

The Albert Smith pessary is best introduced into the vagina when the patient lies on her back with knees drawn up, or in the knee-elbow position. If she lies on her back, the physician may sit down, and after first examining the vagina, the parts having been douched and cleaned, must make sure that the uterus is pressed into normal position as nearly as possible, with the finger or sound. Then judging, as well as may be possible, how large an instrument will be required, a suitable one should be selected and introduced in the following manner: First, with the index-finger of the left hand, palm surface down, inserted into the ostium vaginæ, press the perineum downward toward the anus as much as possible without causing pain. Then, with the thumb and index-finger of the right hand, the pessary, thoroughly oiled, is seized near the narrow end, and the wide end is placed perpendicularly in the vagina, when it can generally be easily introduced. As soon as the wide end has slipped through the ostium vaginæ an inch or more, the index finger of the left hand must be removed from the vagina in order to take hold of the narrow, now the proximal, end of the pessary, and turn it one-fourth around. Then, passing the index-finger of the right hand from below upward into the vagina and through the pessary near the wide end, sufficient downward pressure can be made upon the further end of the pessary to cause it to slide under the cervix, when it will be found to have assumed the position which is well illustrated in Fig. 2850.

If the patient readily consents to take the knee-chest position, the physician will stand by her, and after making all necessary preparations will, with the index-finger of either hand, press the perineum toward the anus. Some little time should be taken to thoroughly distend the perineum, as such procedure will greatly facilitate the introduction of the pessary. Then, with the disengaged hand holding the small end of the well-oiled pessary, the wide end is inserted just under the distended perineum, while the pessary itself is held almost parallel to the thighs, and the instrument is gently and slowly pressed through the ostium vaginæ. The hand holding the pessary must not relinquish its grasp of the instrument, nor let it escape entirely into the vagina, until one index-finger is passed into the vagina and underneath the posterior bar of the pessary, that this part may be raised up when the instrument is slipped into place. There is but little choice between the two methods of introducing the instrument. Whichever position the physician is most accustomed to will be the best.

If it is found that the instrument does not seem well fitted to the parts it should be removed at once.

To remove an Albert Smith pessary, the patient should be made to lie upon her back in the manner just described for the introduction of the pessary. The index-finger of the left hand—or right hand, if this is better educated—previously well oiled, must be passed into the vagina, pressing it far backward underneath the cervix, and laterally over either side of the pessary as near as possible to the posterior bar. Then, by pressing the pessary downward and withdrawing it at the same time, it will instantly slip out from under the cervix, and by gentle traction may be removed from the vagina in precisely the same position as it was introduced. If there seems to be considerable cystocele, the same Albert Smith pessary can easily be made to relieve this condition as well as the retroversion. It is only necessary to cover two thirds of the instrument, beginning at the smaller end, with the transparent rubber gauze such as is used for protecting vaccine points. This may be made quite tight and adherent to the pessary if it be heated, by passing it quickly before the fire or an alcohol lamp, or by holding it for a moment in the warm hand.

By thus fitting, a pessary may be changed so that it may be of far more service. The rubber gauze is quite inexpensive. I experimented by using ordinary elastic rubber bands, but found the gauze much lighter and quite as effectual, as it can be wound tightly around the pessary and instantly made impervious to water by the application of gentle heat, sometimes merely that of the hands.

If there should be a voluminous vagina and the typical Albert Smith pessary is too easily forced down, an instrument with different curves must be selected. The Hodge pessary, which is here shown (Fig. 2851), is one that will often be of service in such cases. It is noticed that this instrument is shorter, and has the same irregular letter-S curves in one direction, but is decidedly less wedge-shaped; in fact, it approaches more nearly to the shape of a ring pessary. The Emmet curved Albert Smith pessary is simply a pessary with a more obtuse anterior angle than the Albert Smith retroversion, and has a more acute anterior angle than the Hodge pessary. The difference in the action between these three instruments is but slight, and undoubtedly the Hodge, or Emmet curve, has no advantage over the typical Albert Smith instrument, except in very exceptional cases. Such cases are those of patients with somewhat open vaginæ from loss of perineum, and ner-

Fig. 2851. The Hodge Retroversion Pessary.

vous patients who cannot well bear to feel the end of the common Albert Smith pessary near the meatus urinarius.

In that class of patients where there is a prolapsus of a hypertrophied ovary or Fallopian tube, Dr. Thomas's bulb retroversion pessary is a decidedly useful instrument. As seen in Fig. 2852, it is a narrow Albert Smith retroversion pessary with a bulb-shaped posterior bar. These are made, at the present time, of one piece of hard rubber, instead of two as formerly, and as shown in the cut. Of course, this makes it possible and easy to keep them absolutely clean. The instrument is especially useful in retroflexion of the uterus. In such cases, however, it is absolutely essential that the bulb-shaped posterior end should press far up behind the uterus, above the angle of flexion. Of course, if this, or any other retroversion instrument, presses against the organ exactly at the angle, thus pressing into it, as it were, it will undoubtedly only make it more acute and troublesome. This instrument can be easily bent, like all hard-rubber pessaries, and thus made wider, if required, to fill a larger vagina. Or it can always be bent quickly into a modified Gehrung anteversion pessary. By simply oiling and heating the sides just back of the bulb-shaped posterior end, this end can be bent upward and backward toward the narrow or anterior end, and this bulb-shaped, wide end will then raise up the anterior wall of the vagina just in front of the cervix. This makes a very useful instrument for so-called anteversions, which are attended with prolapsus of the anterior wall.

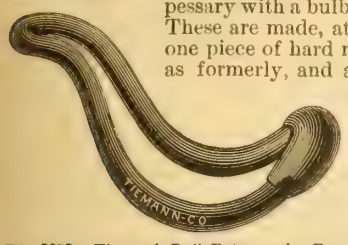

Fig. 2852.—Thomas's Bulb Retroversion Pessary.

Or, if it is desired to have a larger bulb than this one, or one of softer material, it can always be made by wrapping some absorbent cotton around the bulb and covering it with the rubber gauze, and then warming it slightly. No moisture can then reach the cotton, and it will remain clean in the vagina for two or three weeks.

The Ring pessaries, as before stated, act principally by distending the vagina at or near the cervix, raising the latter at the same time from the floor of the vagina. They are made of hard rubber; soft, distensible rubber filled with air; copper wire covered with soft rubber; and also of elastic material, like whalebone or steel, covered with soft rubber. A simple ring pessary is shown in Fig. 2848. The elastic ring pessary was formerly very much used, but is discarded by the great majority of gynecologists at the present time, simply because it may, and often does, become imbedded in the soft tissue on either side of the floor of the vagina, where the pressure is continuously being made. The rubber air-ring pessary will mould itself more easily to the shape of the canal, and consequently is far safer to use. It will be found to be of great service in retroversion and prolapsus in unmarried women, where a hard-rubber instrument could not be introduced without great pain. I cannot see, and have never been able to see, any advantage in a hard-rubber ring pessary over a common Albert Smith pessary, but rather exactly the contrary. One reason why this style of ring pessary has become so unpopular is because it distends the vagina in such an unnatural way, making it unduly wide just at the cervical junction. We consequently would not expect, nor do we get, so many cures after using this instrument.

The Anterior Support Pessary.—This class of pessaries is made up of a vast number of good and bad instruments. I do not call them anteversion pessaries as often as do some of my colleagues, still they do prevent displacement of the uterus forward by stretching the vagina, which helps to make up the utero-vesical septum. Of course, when this tissue is put on the stretch by pressing up the vagina beneath the bladder, it must of necessity draw up the cervix, since the vagina is attached here to the anterior portion of the cervix. Then, if the pressure is continued, it is possible to have a more direct force given to the anterior portion of the body, as the two walls of the bladder are pressed directly against the anteverted uterus.

Among the more useful anterior support pessaries is the instrument called the Gehrung anteversion pessary (Fig. 2853).

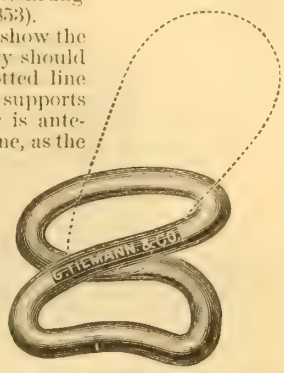

Fig. 2853.—Gehrung Anteversion Pessary.

The figure is intended to show the manner in which the pessary should lie in the vagina. The dotted line is intended to show how it supports the uterus when the latter is anteverted. The cut is a poor one, as the uterus never should fall as far forward as is here pictured. The principle of its action is to hold up the anterior wall, while on either side of the cervix rest the curved anterior portions of the instrument. The pessary, when properly adjusted, is an excellent one, and serves equally well in a sharp anteversion as in those cases of prolapsus uteri which only take place as a result, or an accompaniment, of a prolapsus of the anterior wall of the vagina. In other words, keeping up this anterior wall prevents a bad prolapsus uteri in many cases. There are three objections to this instrument:

First, the impossibility of its retaining its proper position in the vagina if it is one size too small. Second, the difficulty of deciding when it is exactly *in situ*, unless one is accustomed to handle the instruments daily. Third, the difficulty of introducing it. The last difficulty can be overcome, however, if my rule for introducing the instrument is followed. The first objection cannot always be avoided, since it is impossible to determine before using just what size to apply in any given case. The second objection is a corollary of the first. I have often been obliged to remove instruments which had been improperly adjusted by another physician. The four curves, all of about the same angle, are very confusing to one who examines the instrument *in situ* for the first time. The rules which I am in the habit of giving the class at the post-graduate college are the following:

Have the patient resting on her back on the table in front of you, her feet drawn up on a level with the table. Anoint the instrument which has been selected, after examining the size of the vagina, and place it on the table in front of you; then study the instrument with special reference to the symmetry of the *opposite curves*, when it is seen that *two* of the *curves are symmetrical*, and *two* are *not symmetrical*. You will at once place the two unsymmetrical curves nearest you, and of course the two symmetrical curves will be nearest the patient. Then the bottom of the pessary must *always be* that part which is longest. You then have the shape of your instrument fully understood. Remember that the two symmetrical sides are to rest, the one on the right, the other on the left of the cervix; also, that the longest part of the pessary is to rest on the floor of the vagina, and the shortest part against the roof of the vagina. After this study of the instrument is made it should be introduced as follows: Seize the part of the pessary which is to rest directly under the bladder, and turning the instrument directly over, insert either of the symmetrical curves in the vagina, opening the vagina with the fingers of the opposite hand, and pressing this curve inward until it is possible to insert the opposite symmetrical curve. Then rotate the instrument backward to the original position, as it slides into its resting-place with the longer portion on the floor, the shorter against the roof of the vagina, and the symmetrical curves one on either side of the cervix.

The same motions, in reversed order, should be made on removing the instrument.

The instrument is a very useful one, but will never become as popular as some other forms of pessary, simply

because the physician gets confused in his attempts to understand the method of introduction

The globe anterior support pessary, though a very different-shaped instrument, really prevents prolapsus in much the same way viz., by keeping a constant pressure from below upward, against the roof of the vagina. This instrument is seen in Fig. 2854. It is made of glass, hard rubber, or silver, and must always have a string attached to it, in order that the instrument may be removed occasionally and cleansed. It is especially serviceable in cases of cystocele and prolapsus uteri in aged single women. It can be worn with safety for three months. These pessaries are made of various sizes, and are easily introduced by anyone.

Fig. 2854.—Globe Pessaries.

There are very many other anteversion pessaries which are made to ride altogether in front of the cervix. Some of them may be very useful, but from a large experience with them I am sure none is better, or as good as those already described. There are, moreover, the anterior support pessaries, which are made to press up against the posterior fornix. These are really very *excellent* instruments for the relief of anteversion, with prolapsus uteri, or when complicated with cystocele. Among the most valuable, is the Thomas hinge-cup anteversion pessary,

Fig. 2855.—Thomas's Hinge-cup Anteversion Pessary.

Fig. 2855. This instrument is made of hard rubber, and as seen in the cut is closed, while the dotted lines show how the instrument will appear when opened for cleaning or for introduction. It will be noticed, on examination, that the lower portion of this instrument is a simple Albert Smith pessary, while the upper, or cup part, is attached to the broad end of the retroversion pessary by means of a well-made hinge. This cup is intended for the cervix to rest in; and the side of the cup opposite to the hinge is the support for the roof of the vagina. By heating the pessary at the hinge, and bending it here, the cup may be raised higher and thus press up the anterior wall so high that it will be quite impossible for the patient, by forcing downward, to expel the instrument. This instrument should generally be opened when it is proposed to introduce it into the vagina. The patient should lie in the dorsal position. The instrument having been well anointed, the cup part should be introduced first. By introducing it turned one-fourth over, the cup part will slip in easily. When it and the hinge part have passed through the ostium vaginæ it should be rotated backward, the acute end of the under pessary should then be raised and the instrument pressed downward and into the vagina. The cup part meeting the cervix is turned backward and the cervix finds its position, and immediately the pessary is *in situ*. To remove this instrument, pull on the angle nearest the ostium vaginæ, and it is easily extracted.

Sometimes when the perineum has been destroyed, or is very distensible, the instrument can be inserted closed, after pulling down the perineum.

I have had, during the last fifteen years, not less than twenty different women wearing this instrument for the relief of complete prolapsus uteri, and I know of no instrument which serves this purpose so well. Many of these patients could not be persuaded to try other instruments. I have myself tried to make an instrument which would meet the same indications, and at the same time avoid the only objection to Dr. Thomas's instrument, viz., the hinge. And I have had made for me the instrument shown in Fig. 2856, and called Hanks' anterior support pessary. It holds

Fig. 2856.—Hanks' Anterior Support Pessary.

the anterior wall, it steadies the cervix, and presses up against the posterior fornix. It can easily be bent to suit each case. I like the instrument because there is no hinge to clean. It is introduced in the same manner as an Albert Smith pessary.

Dr. Skene has devised a very useful anterior support instrument, a cut of which is seen in Fig. 2857. It acts like Dr. Thomas's anterior support pessary, but does not

Fig. 2857.—Skene's Anterior Pessary.

remain *in situ* so well. It is introduced like an Albert Smith pessary.

Dr. Skene has also invented a very ingenious instrument for use where there is a prolapsus of the anterior wall, with a vesico-vaginal fistula. It is seen in Fig. 2858. The cup rests under the fistula and catches the urine as it dribbles from the bladder. The urine is carried off by a tube to a rubber bag worn on the thigh. It is introduced like the Albert Smith retroversion pessary.

The last anteversion pessary which I wish to describe is the useful little instrument called the Graily Hewitt rocker anteversion pessary, and which is pictured in

Fig. 2859. This instrument, as is seen, presses up against the roof of the vagina, while the cervix is expected to ride in front of the posterior bar. It therefore

Fig. 2858.—Skene's Vesico-vaginal Fistula Pessary.

steadies the cervix as well as presses up the prolapsus of the bladder, etc.

The two symmetrical curves are to rest, the one back of the cervix, the other on the perineum below the meatus. The instrument is especially useful in young unmarried women suffering from displacement of the uterus forward, especially when attended with a sinking of the anterior wall. The pessary is easily inserted by turning it one-quarter around and pressing the end which is to pass under the cervix through the ostium vaginæ first; then, when one-half the instrument is in, by rotating it backward, as it is to rest in the vagina. Sometimes it is quite easy to press in the instrument as it is to remain, after pushing the perineum downward as far as possible.

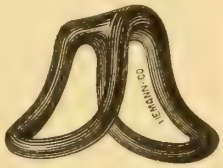

Fig. 2859.—Graily Hewitt Anteversion Pessary.

Before closing the description of anteversion pessaries, I wish to again call attention to the danger of using them when any inflammation exists in front of the uterus.

The external support pessaries are also very numerous. A few are really very useful, and I can safely recommend them when there is complete prolapsus uteri, and when the Thomas hinge-cup, the modified Gehrung, or the globe pessary does not prevent the complete extrusion of the uterus. These pessaries are never needed for simple retroversion or anteversion, but only for complete procidentia uteri. The most comfortable and most eas-

Fig. 2860.—O'Leary Pessary.

ily adjusted pessary of this class which I have ever used is the O'Leary instrument (Fig. 2860).

It is easily understood, and is easily introduced. It holds the uterus very gently because of the coil spring in the stem, and the outer wire attachment for the stem can, and does, adapt itself to the shape of the parts. A very similar instrument, but less expensive, is the Hornby pessary (Fig. 2861). The stem in this, however, is slightly curved, and does not have the coil spring.

Dr. Thomas has devised a number of external support pessaries, all of which are very similar in their action to the Cutter instrument.

The Cutter external support pessary, as seen in Fig. 2862, is an instrument much used, and is simple in mech-

Fig. 2861.—Hornby pessary.

anism and easy of insertion. It is worn with comfort, and is not expensive.

The lateral expansion pessaries are not so numerous. They are made to open when they have passed into the vagina, and the lateral wings, when opened, rest against the vagina as it covers the ischio-pubic rami. Of course, when the screw of the stem is turned, and the wings are opened (Fig. 2863), it is quite impossible for the uterus to prolapse completely. It is an instrument which can

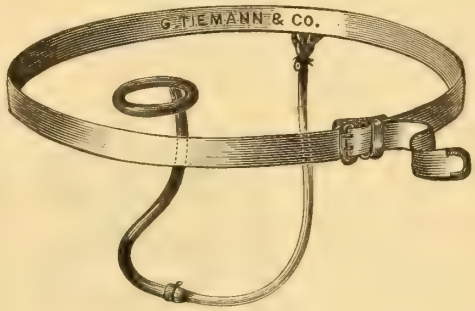

Fig. 2862.—Cutter Pessary.

be trusted to hold the uterus, but it is sure to press so steadily in one position that an ulcer will often be formed in less than a week. It must, therefore, be carefully watched.

We come now to the last division of pessaries, as we have classified them, viz.: *The intra-uterine stem pessary.* In this field, too, so many have worked that there is a multitude of this class of pessaries. Several are useful, and others would be equally so were it not too difficult to introduce them. But really only a few varieties are needed.

Fig. 2863.—Zwenck's Pessary.

By many gynecologists the stem pessary is not used at all. For fully fifteen years, up to 1875, the stem pessary was not even recommended by writers or teachers of gynecology. The instrument was considered dangerous, even in the hands of such distinguished physicians as Velpeau, Kerwisch, Detschay, Simpson, Vallaix, and their pupils and admirers. Twenty years ago, in 1866, Dr. Sims wrote that he knew of but three physicians in the United States who advocated the use of the stem pessaries. These were Drs. Peaslee, Conant, and Mack. Three years later Dr. Thomas thought no one advocated their use, and believed them to be dangerous instruments to use. In 1868 Dr. Peaslee read a paper on this subject

before the Medical Society of the State of New York, and recommended them for certain pathological conditions. He had never given them up in private practice during the season of their unpopularity, and when we remember how judicial he was in all his conclusions, we must believe that his experience was worthy of our consideration.

Since this time a large number of British and continental gynecologists, as well as a host of our American colleagues, have advocated their use. Among them we find the names of Aveling, Williams, Athill, Hewitt, Bantock, Schroeder, Martin, Winckel, Olshausen, Peaslee, Thomas, Van der Walker, Chadwick, Goodell and others.

Fig. 2864.—Stem Pessary.

The great caution to be observed is to use only absolutely clean instruments, to watch them carefully, and to remove them as soon as danger threatens.

Fig. 2864 represents the common glass stem pessary.

It is a useful little instrument, very inexpensive, easily kept clean, and easily introduced. The lower end rests in a little cup-shaped pessary, or it may be retained *in situ* by means of a cotton tampon, which must be often changed.

Another instrument, called the Conant stem pessary, is shown in Fig. 2865. The upper cut shows the instrument open, and the two lower cuts show the instrument as it looks when closed and as it appears from two sides.

When being introduced into the cervical canal the wings must be closed. After the stem has passed up the cervical canal the wings are opened, and thus they support the stem *in situ* by riding upon the floor of the vagina.

Another stem pessary has been devised by Dr. Thomas, and is called the galvanic stem pessary. It is composed of alternate beads of zinc and copper strung on a wire attached to a ball, as is seen in Fig. 2866. It is expected to exercise some galvanic, and, correspondingly, some curative, influence at the point diseased, or bent, or contracted. It is kept in place by means of a ring pessary or cotton pledget.

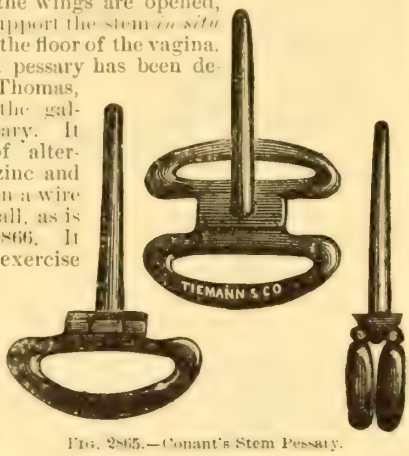

Fig. 2865.—Conant's Stem Pessary.

All these intra-uterine stem pessaries are supposed to straighten the distorted or bent canal by actual pressure against the walls of the canal. If they are kept *in situ* some time the blood vessels are enabled to do their work more perfectly, and the malnutrition of the parts must be improved. Of course, the galvanic pessary may be a source of stimulation by reason of the mild galvanic influence, besides acting as a splint, like other stem pessaries.

Fig. 2866.—Thomas's Galvanic Stem Pessary.

Certain retroflexions, it seems to me, can be more quickly cured with a Conant, or glass, or hard-rubber stem pessary, than in any other possible way. It is only necessary to introduce the stem, after placing the patient in the Sims or the knee-chest position, and then pack the lower part of the vagina with cotton pledgets to keep either of these in their proper position. I do not describe any of the many other stem pessaries, because the simply constructed instruments here pictured meet and overcome as effectually every pathological condition as the more complicated ones possibly can.

The Length of Time that a Pessary may be left in Position.—We cannot do better than to consider more connectedly and methodically the very important subject of the length of time that any or all pessaries may safely be allowed to remain in the vagina. The length of time must vary, of course, in different individuals, and at different periods in the progress of the displacement, and, finally, with the kind of pessary selected. Some of these conditions have particular reference to the patient herself. I believe a general rule can be followed in all cases—one which can be easily remembered, and to which I can conceive of but few contra-indications for its universal application. It is as follows: When there is a prolapsus, or version, or flexion of the uterus, with more or less fixation from a former inflammation around the organ, resulting in an exudation, or in the shortening of either of the broad ligaments, or of either of the utero-sacral ligaments, if in such conditions a pessary is used at all, it must not be retained more than six hours after being first introduced, without learning from the patient if it has or has not produced pain. Then its action should be tested by careful examination while the patient stands erect with one foot resting on a support six inches from the floor; also, by examination while the patient is recumbent in the dorsal position on a bed. After all this precaution, if it is found that the instrument is well adjusted it may be allowed to remain for four or five days. And on later trials and examinations, if all has gone well, it can remain for two or three weeks, never longer. The foregoing rule applies, of course, to the use of any pessary during the acute or chronic stage of peri-uterine inflammation, or during the convalescence from such condition. A second general rule should also be followed, which is, however, but a corollary of the first, viz.: Avoid using pessaries altogether for the relief of pelvic pains if you cannot diagnosticate such conditions if present. When cases of this class, complicated with peri- or para-metritis are excluded, it will be seen that we at once come to consider the time that individual pessaries may be kept *in situ*.

The Albert Smith pessary, the lever wedge-shaped pessary, can be worn, when well adjusted, longer than any other kind, as the principle on which it acts allows of a slight change of position, and, consequently, it does not, even when large, so quickly cut its way into the vaginal wall. The patient should be seen within three days after the pessary has been introduced, and every three or four weeks afterward. The ring pessary, whether stiff or elastic, should never be allowed to remain over twenty-four hours on its first introduction. If, on examination, it shows no tendency to embed itself laterally in the vaginal mucous membrane, it may be allowed to remain one week, never longer, and then it must be removed, and a careful inspection of the parts is to be made. Then, if all is right, it can remain three weeks, but not longer, unless the pessary is a very small one, when it will be quite useless to introduce it at all.

The globe pessary, whether of hard rubber, of glass, or an air-ball, is especially adapted to elderly single women. As there are no sharp or rough angles on first introduction it can, if not too large, remain *in situ* for one week. On introducing it at later times it can remain with safety and comfort for six weeks or more.

The different varieties of so-called anteversion pessaries are more dangerous instruments than those of the first or second class.

The Gehrung, Graily Hewitt, Thomas hinge-cup, and all the others which fall under this classification, ought never to be allowed to remain without careful examination every day for a few days. And any pessary of this sort should be removed, the parts well douched, and the instrument thoroughly cleansed at least every four weeks.

The Thomas hinge-cup pessary, however, in the case of quite old people, can be allowed to remain for two months; but it is the best practice by far to follow the rule of removing all pessaries every month. The external support pessaries should be withdrawn every night and replaced every morning. The lateral ring pessary, or the Zwenck, like the external support pessary, must be removed every night and re-inserted every morning,

and on no account should it be allowed to remain longer than one day.

The stem pessary of every variety must be carefully watched, and the patient should be directed to report her condition daily for at least a week, and afterward every five or six days.

Dangers attending the Use of Pessaries.—That there are no accidents that can possibly occur from the use of pessaries, the most ardent advocate of their use will not dare maintain. We have all seen pelvic inflammation occasioned, violent vaginitis produced, and most intense pains excited by improperly selected instruments.

When, as has been stated above, there exists a peri-uterine inflammation, or the result of such an inflammation remains and keeps the uterus more or less fixed in a retroverted state, any pessary may, and generally will, excite additional trouble, instead of relieving the impaired circulation and malnutrition. It is impossible to exercise too wise judgment in selecting a pessary, too much caution in its introduction, or too much watchfulness while it is being worn, if such condition exists.

I advise all to avoid the use of pessaries in such cases unless the patients can be seen every one or two days. The Albert Smith, or the ring pessary may sometimes press so tightly under the urethra that the patient will be unable to pass urine. Such an accident may occur simply from using too large or too long instruments, especially when the uterus is partially fixed and the pessary, in consequence, is not well balanced, because the posterior portion in the posterior fornix being very low, the anterior angle, the upper extremity of the lever, will press upward too far. The elastic ring, or the hard-rubber ring, may easily become imbedded in the vaginal mucous membrane when the instrument is over-large. The finger must be passed up and down laterally between the vaginal wall and pessary, and the instrument changed if found to be too tightly fitting. The globe pessary, if there is no string, or if the string should become detached, may occasion a little anxiety because of the difficulty of its removal. A small wire, however, can be bent upon itself and passed above the instrument, and by a simple manipulation it can be removed as a cork is removed from the inside of a bottle. Or the same object can be easily obtained by using the placenta forceps. The cervix, when conical, may sometimes become incarcerated in the Thomas hinge-cup pessary, or the Graily Hewitt rocker pessary, or the Hanks prolapsus pessary, or any one of the so-called anteversion pessaries, and also in an external support pessary where the cervix rests on a small ring. It is only necessary to remove the instrument very gently from the parts, pressing with a finger the cervix upward out of its place of fixation in the ring before traction is made upon the instrument. If from any cause a pessary is allowed to remain too long, and becomes imbedded in the vaginal tissue, and granulations spring up and completely cover some parts of the instrument, a pair of bone forceps may be called into use to cut the hard-rubber instruments, but it is always safe to cut with a scalpel directly through the new growth down upon the pessary and thus remove it whole. The severe abrasions and erosions which poorly adjusted pessaries sometimes occasion can always be quickly cured if the parts are frequently douched with a hot antiseptic solution, followed by a direct application of some stimulating astringent. Should a prolapsed ovary become incarcerated below and behind the posterior bar of any retroversion pessary, and, as generally occurs in such cases, a most intense pain be occasioned, it is only necessary to gently remove the instrument while the patient is directed to keep the knee-chest position for an hour or more.

Whenever evidence of acute pelvic inflammation appears directly after a pessary has been introduced, the instrument must be removed at once, and the best means at our command called upon to stay the progress of the disease. Such an accident often follows the injudicious use of a stem pessary, and, as stated under another head, the patient should be watched daily until the instrument is found to be really a comfort to the patient. She should not be allowed to walk about much, nor take a long journey until it is absolutely certain that she can do so with safety. This class of instruments will, of course, be a great source of danger if they are not absolutely aseptic. And undoubtedly these inflammations have often been occasioned by sepsis rather than by traumatism.

Horace T. Hanks.

PETERSTHAL is a spa lying in the Schwarzwald of Baden, in a valley about 1,400 feet above the level of the sea. The climate is mild. There are several springs of carbonated iron waters. The following is the composition of two of these, calculated in parts per thousand.

	Petersquelle.	Salzquelle.
Bicarbonate of iron	0.046	0.045
Bicarbonate of manganese	trace	trace
Bicarbonate of sodium	0.067	0.040
Bicarbonate of calcium	1.518	1.501
Bicarbonate of magnesium	0.455	0.584
Chloride of sodium	0.033	0.042
Chloride of lithium	0.004	0.002
Sulphate of sodium	0.790	0.852
Organic matters, etc.	0.127	0.176
Total solids	3.040	3.242

There is a large amount of free carbonic acid gas.

The waters are used both internally and externally, and, in addition, pine-needle baths and mountain-climbing in the pine-woods are prescribed in suitable cases.

Petersthal is frequented chiefly by persons suffering from anæmia, and those who are run down by overwork or from other causes.

T. L. S.

PETROLATUM. The word *petrolatum* stands, both in Latin and English, as the officinal title in the U. S. Pharmacopœia (revision of 1880) for an unctuous derivate of petroleum, representing the substances so well known and popular under the proprietary names of *vaseline* and *cosmoline*. The petrolatum of the Pharmacopœia is thus defined: "A semi-solid substance, consisting of hydrocarbons, chiefly of the marsh-gas series ($C_{16}H_{34}$, etc.), obtained by distilling off the lighter and more volatile portions from American Petroleum, and purifying the residue. Melting-point about 40° C. to 51° C. (104° F. to 125° F.), the first constituting the softer, and the second the firmer, variety. When Petrolatum is prescribed or ordered, without specifying its melting-point, the low-melting variety, which liquefies at about 40° C. (104° F.) is to be dispensed." As above said, petrolatum consists principally of a mixture of paraffins (hydrocarbons of the formula C_nH_{2n+2}), but probably also contains some olefins (hydrocarbons of the formula C_nH_{2n}), which, by their softer consistence than that of the corresponding paraffins, tend to increase the unctuousness of petrolatum. Petrolatum appears as "a yellowish or yellow, fat-like mass, transparent in thin layers, more or less fluorescent, especially when melted, completely amorphous, tasteless, and odorless, or giving off, at most, only a faint petroleum odor when heated, and having a neutral reaction. When gently heated, until the mass is almost entirely melted, the liquid portion has a specific gravity ranging from 0.835 to 0.860. It is insoluble in water; scarcely soluble in alcohol, or in cold absolute alcohol; but soluble in 64 parts of boiling absolute alcohol, and readily soluble in ether, chloroform, disulphide of carbon, oil of turpentine, benzine, benzol, and in fixed or volatile oils. When heated on platinum foil, it is completely volatilized without emitting the acrid vapors of burning fat or resin" (U. S. Ph.).

Petrolatum owes its medicinal value to its combining with the physical attributes of the semi-solid fats the chemical peculiarity of the paraffins, of being practically unalterable and indifferent to chemical agents. Petrolatum neither hardens nor turns rancid by exposure, and can be treated with any chemical likely to be medicinally prescribed in an ointment without being itself attacked thereby. The substance is therefore available, either by itself as a simple unguent, perfectly bland and changeless, or as the fatty basis for medicated ointments.

Edward Curtis.

PHARMACOPŒIA (Greek φαρμακοποιία, from φάρμακον, medicine, remedy, and ποιεῖν, to make, to prepare; Latin, pharmacopœa or pharmacopœia; German, Pharmakopoe; French, pharmacopée; Spanish, farmacopea, etc.). A *pharmacopœia* in the modern sense, may be defined as a work published by some recognized authority, for the purpose of securing uniformity in the kind, quality, strength, and composition of simple and compound remedies used in the practice of medicine. It may either be of a local character, or it may apply to a whole country. The term has also been often applied to works written or published by individuals, without the official sanction of some governmental or professional authority. The Greek word φαρμακοποιΐα occurs in later Greek medical writers under its proper meaning, "the preparation of medicines," or "the art, or business, of preparing medicines." As the title of a book treating of this subject, however, it is probably not older than the beginning of the sixteenth century.

Ancient and Mediæval Precursors of Pharmacopœias.—While the ancient nations did not possess any works which could be fully set side by side with our modern pharmacopœias, yet the gradually accumulating mass of facts relating to the preparation and practical use of medicines resulted in the composition of numerous works treating at least incidentally of this subject. In giving an account of the literature relating to the latter, we shall confine ourselves to those works the influence of which has extended to our times in one way or another.

Egypt has furnished us the oldest existing documents containing formulas and directions for the preparation of medicines. The oldest known is the Papyrus Ebers (discovered by Professor Ebers, in 1872), dating from the year 1552 B.C. (compare *Medical Record*, xi. (1876), 247–251). This remarkable work shows that the knowledge of medicine, surgery, and materia medica had attained, already in that early period, a condition of development and stability approaching in many respects to fixed dogmatism, but nevertheless exhibiting a remarkable faculty of diagnosing diseases from symptoms, due allowance being made for the imperfect knowledge of anatomy and physiology attainable at that period. The Papyrus Ebers mentions a large number of simple remedies, and also contains numerous formulas of compounds, often in form of regular pharmacopœial receipts, accompanied by signs and terms expressing weights or measures, precisely as is customary at the present day.

Of equally great interest, though a few centuries younger, is the medical papyrus of Berlin (see Woenig, "Die Pflanzen im alten Aegypten," Leipzig, 1886), written about 1350 B.C. This document contains a great number of formulas, with exact statements as to ingredients, and weights and measures, all, however, in quite a laconic manner, as if written for persons accustomed to an old-established system, which was indeed the case as we know from other sources. These formulas comprise internal and external remedies, among them embrocations, salves, cataplasms, plasters, enemata, potions, decoctions, etc. The remedies themselves are simples, most of them plants or derived from plants (such as certain gums and resins); a few metals (iron, and soda in some form); liquids, such as wine, water, vinegar, honey, human and other milk, human urine, the fæces, bile, blood, etc., of various animals, etc.

In addition to these written documents, there existed also formularies sculptured in stone. Such a formulary or pharmacopœia was discovered by Professor Dümichen upon the walls of a regular pharmaceutical laboratory (*sic!*; see Woenig, l. c., 372) in the temple of Edfu.

India.—The existing literature, reduced to writing at a much later period than that of Egypt, and originally transmitted by oral tradition only, might be supposed to contain at least fragments of a science of medicine or of pharmacy existing in ancient times. An examination of the oldest literature, however—that of the Vedas, Brahmanas, and Sûtras—reveals only a very circumscribed and crude knowledge, disease being chiefly ascribed to supernatural causes and its removal to the efficacy of charms and incantations. It is certain, contrary to what has been believed, even in quite recent times, that a regular system of medicine was not developed in India until the medical literature of the Greeks gradually found its way east, partly tinged with the medical creeds existing in the countries through which it passed. This much only is so far positively known, that the principal medical works of the Hindus, viz., those of *Charaka* and *Sugruta*, cannot be traced farther back in their present form than the eighth century A.D. (see *Nat. Remedies*, 1876, 229). Between these works and the later Hindu medical literature there is a considerable gap of time, some four or five centuries elapsing before we meet with other notable writers on medical or therapeutical subjects. Most of these medical works, including *Charaka* and *Sugruta*, contain numerous formulas and directions for preparing medicines, but they have lost a good deal of their distinctness and perspicuity, owing to the poetical (metric) form in which all these works are written. Among the later medical treatises the most important are the "Ashtângahridaya," by Vâgbhata, and the "Bhâvaprakâça," by Bhâva, both of them only a few centuries old. These contain, likewise, many formulas interwoven in the text. Regular treatises on pharmacy, or formularies, are not numerous (to the former belongs the "Prayogâmrita" of Vaidyachintâmani, and others); but treatises on materia medica, or glossaries of simples, are much more common. The most extensive of these is the "Nighanturâja," by Narahari, of Cashmeer, being a dictionary of products of nature, etc., with synonyms. Another smaller but useful work is the "Madanavinoda" of Madanapâla.

Greece.—The first historical personage appearing upon the stage of Greek medicine, and at the same time the most important through the far-reaching influence of his teachings, was Hippocrates (about 460–377 B.C.). The treatises composed by, or attributed to, him contain numerous directions for the preparation of certain medicines, but among his genuine writings there is none exclusively devoted to this subject. In fact, there is no evidence that the pharmaceutical art was in a very forward state of development at that time in Greece; but it became gradually developed during the subsequent centuries, in proportion as the rational treatment of diseases, upon the foundation laid by Hippocrates, spread through the cultivated nations of Europe and Western Asia.

Omitting the names of those whose works are lost, or whose writings remained without special influence upon the formularies of later times, we may next mention Andromachus, of Creta, Nero's court-physician, who wrote (about 60 A.D.) a sort of formulary in iambic verse, and who is also the author of a poem on theriac and its preparation. This compound played an important rôle for many centuries subsequently, and, even at the present day, still haunts more than one pharmacopœia in a more or less disguised form. At about the same time (65 A.D.) Servilius Damocrates (or Democrates) composed various pharmacological poems, one of which also treats of theriac. This compound, when prepared according to his directions, was subsequently known as "Confectio Damocratis."

Of paramount importance for the development of materia medica was Pedanius Dioscorides, of Anazarba, near Tarsus, in Cilicia, whose work, ὑλικά ("Materialia," written about 78 A.D.), is a most valuable cyclopædia of simples, in which the latter are carefully described and discussed, and which became one of the chief sources of pharmacological writers down to the middle ages.

No author need now be mentioned until the time of Claudius Galenus, of Pergamus (131–ab. 210 A.D.). In the numerous writings, partly genuine and partly suppositious, which bear this great physician's name, many formulas occur which are used by later writers, and have been handed down as standard recipes. Two of his works treat especially of the composition of medicines, περὶ συνθέσεως φαρμάκων των κατὰ τόπους, "on the composition of medicines according to the places" (of application); and . . . κατὰ γένη, ". . . according to classes." He largely increased the number of complex

("Galenical") mixtures, for the formulas of which he often paid a high price.

Of later writers, the more important are: Aëtius, of Amida, in Mesopotamia (sixth century A.D.), who gives numerous formulas for plasters, salves, etc.; Alexander, of Tralles, in Lydia (525–605 A.D.), and Paulus, of Ægina (seventh century A.D.), both of whom likewise quote many formulas in their writings. Passing now over several centuries, we find no author worthy of mention until we come to Nicolaus Myrepsus, of Alexandria (second half of thirteenth century A.D.), who compiled an "Antidotarium" (δυναμερόν), or formulary, containing not less than two thousand six hundred and fifty-six formulas, in forty-eight chapters. This work was written in Greek, but only the Latin translation has been published (first edition, Basle, 1549). It is also entitled "Antidotarium Magnum" (not to be confounded with the "Antidotarium Parvum" of Nicolaus Præpositus). In spite of its encyclopædic character, this formulary did not acquire as much reputation as the less extensive works of Mesue or of Nicolaus Præpositus.

Rome.—Probably the oldest Roman author from whom formulas have come down to us, was the "man of iron," M. Porcius Cato (234–149 B.C.), who interweaves them here and there in his treatise on agriculture. Still, Roman literature hardly presents anything worth mentioning on the subject under consideration, until we come to C. Plinius Secundus, the elder (23–79 A.D.), in whose great work on natural history many subjects are treated of relating to materia medica. The first literary production specially relating to compound medicines, and, in fact, constituting a formulary, is the work of Scribonius Largus (first century A.D.), "Compositiones Medicæ," written in barbarous Latin, but of importance for the history of therapeutics of that period. This work, among other matters, contains the first correct description of the method of obtaining opium. Some valuable works of other authors, dating from this period, and referring to our subject, are lost. We might, however, mention Rufus, of Ephesus, whose treatise on cathartics has been the starting-point of various formulas subsequently in common use. As most of the medical writers of Rome, or of other parts of the Roman empire, preferred to write in Greek, the Latin literature offers but few works of any importance for our purpose.

Arabic Countries.—With the gradual decline of the Roman empire, culture and science tended toward Constantinople, but no progress is recognizable in the medical literature of this time, since it had become almost an axiom blindly to follow the teachings of Galen and Hippocrates. Through the advent of the Arabs, however, new life was infused into the torpid condition of the medical and other sciences. They were also the first who developed the art of the apothecary, and established official regulations for the exercise of his profession. These regulations related to the quality and price of the medicines, and prescribed which of the remedies mentioned in the dispensatories of that period were to be kept in stock for instant use. These features were subsequently copied by western nations.

At the end of the ninth century, Shâbûr ben Sahl wrote a sort of dispensatory under the title of "Ibdâl" (Haji Khalfa, ed. Flügel, i., 142), and about the middle of the twelfth century Abû'l Hassan Hibet-allah ibn Talmid composed a similar work, entitled "Krabadin" or "Grabaddin" (Arabic, *qarâbâdîn*, or *qrâbâdîn*), which was commonly followed by Arabic apothecaries. The most important of these works was that composed by the younger Mesue (Mâswîyah el-Mârdinî, died 1015 A.D.), of Maridin, on the Euphrates, and of which only the Latin translation is extant, under the title "Antidotarium, seu Grabaddin Medicaminum compositorum." This remained for a long time the chief canon of pharmacy. It contains a large number of formulas arranged in twelve chapters, each treating of a different form (for instance, Pilulæ, Cerata, etc.) under which medicines are applied or administered. Not less than four Italian translations appeared of this work previous to the year 1500, and the Latin text was often reprinted.

The writings of the most celebrated of all Arabic physicians, viz., Avicenna (Abû 'Ali Hussain ben Abdallah, Ibn Sinâ, 978–1036 A.D.), also contain many formulas which were incorporated in subsequent collections.

Other writers, whose works contributed in this direction, were Ibn Wâfid el-Lachmi (about 1050 A.D.), called Albenguefit in mediæval literature, whose work on simples has been published only in Latin translation. Serapion the younger (Ibn Serâbî, about 1070 A.D.) was the author of a similar work, but this was much more esteemed and made use of than the former.

The most important Arabic writer on materia medica is Ibn Baitâr (about 1197–1248 A.D.). His work on simples and foods, based on his own observations and on the works of Greek, Arabian, Persian, and Syrian writers, is a perfect storehouse of information, and has exerted considerable influence upon the development of therapeutics and pharmacy among his countrymen.

Persia has little of interest to present in this direction. If we except a treatise on Materia Medica, based upon Greek, Arabian, and Indian sources, written by Alherwî (ninth century A.D.), we meet nothing of interest until the close of the seventeenth century, when Father Ange de la Brosse, de St. Joseph, published at Paris (in 1681) the "Pharmacopœa Persica, ex idiomate Persico in Latinum conversa." That this is no translation of an original Persian work has been recognized many years ago by Dr. Hyde, who supposed it to be the work of Père Matthieu. Leclerc (Histoire de la Médecine Arabe, Paris, 1876, II., 481) reports that it is a translation of an Arabic work existing in manuscript in the National Library at Paris. It bears internal evidence of the intimate acquaintance of the author with European medicines, some of which were probably then unknown to Persians, while others which were known (such as Opium) are omitted. In 1771 Mir Mohammad Hussain, of Khorasan, wrote a Persian pharmacopœia, and subsequently an encyclopædia of materia medica ("Makhzan el-adwiya," "Treasury of Medicines") of considerable merit.

Mediæval Europe.—Up to about the fifteenth century, the apothecaries in European countries situated to the north of the Alps, did not prepare many compounds themselves, owing to the difficulty of importing the numerous, often bulky, and perhaps scarce, crude materials. They were in the habit of obtaining the finished preparations from Italy, where the art of pharmacy was in a flourishing condition. Among the works written during the Middle Ages, which either served themselves as pharmacopœias or formularies, or at least contributed to their compilation, may be mentioned the following: The "Antidotarium" (also called "Antidotarium parvum," to distinguish it from the "Antidotarium" of Nicolaus Myrepsus) of Nicolaus Præpositus, of Salerno (first half of the twelfth century), consisting of about one hundred and fifty alphabetically arranged formulas for compounds. This compilation, together with Mesue's "Grabaddin" (see under Arabic countries), constituted the most celebrated formulary of the Middle Age (first edition, Venice, 1471). Other important works of this period are the following: "Compendium Aromatariorum" (1st ed., Bologna, 1488), by Saladinus Asculanus, a useful and much used work, in which much attention is devoted to the description of drugs and their mode of preservation; "Luminare Majus," by Manlius de Boscho (1st. ed., Venice, 1496), a highly esteemed dispensatory. A counterpart of this is the "Luminare Minus" (Venice, 1517), of Quiricus de Augustis de Torthona. The "Antidotarium Florentinum" (1st ed., Florence, 1489; often reprinted) is the first pharmacopœia or formulary published in Europe under governmental authority.

History of Pharmacopœias.—The literature of pharmacopœias is very extensive, and an exhaustive account is beyond the limits of this work. Yet, since a reliable list or sketch of at least the more important pharmacopœias is often of great use to those who have to consult medical works published in previous years, a condensed account of them is here given, arranged by countries; among the latter being included, for the sake of completeness, most of those which possess no regular phar-

macopœia of their own, but use some other work either from choice or by command.

Note.—In quoting editions of the less important pharmacopœias, only the date of the first one is usually given. A plus sign (+) behind the date indicates that several editions followed. In some cases the date of several or of all editions is given. The word "pharmacopœia" is usually abbreviated to save space.

Argentine Republic.—A commission was appointed some years ago to draft a pharmacopœia, but so far nothing appears to have been accomplished. The "Farmacopea del Pais" is recognized by certain laws, but it is a mere fiction. Of foreign pharm. the French and Spanish are most in use.

Austria-Hungary.—In 1729, the Vienna Pharm. Society published a dispensatory under the title of "Dispensatorium Pharmaceuticum Austriaco-Viennense," which was repeatedly revised and reprinted. In 1739 appeared the "Dispensatorium Medico-Pharmaceuticum Pragense," which also saw several editions. An official Ph. prepared by order of Government by Stoerck, Jacquin, and Well, was published in 1774 under the title "Ph. Austriaco-Provincialis." This was several times revised, and also translated into German as well as into Dutch, the Netherlands at that time forming a part of the Austrian empire. After the loss of the Dutch provinces a fresh start was made, and the first pharmacopœia proper appeared in 1812, under the simple title, "Pharmacopœa Austriaca." The subsequent editions appeared in—1814 (II.), 1820 (III.), 1834 (IV.; this being full of misprints was republished in 1836); 1855 (V.); 1869 (VI). At present (July, 1887) a commission is engaged in revising the work. The Austrian Ph., up to 1871, was valid for the whole empire. In that year a separate Ph. was published for Hungary. In extent, the Austrian Ph. is one of the smallest, containing only 510 titles. The text is in Latin. A supplement was published in 1879. A special Military Ph. had been in existence since 1795, the last revision dating from 1872.

The title of the Hungarian Ph. is: "Magyar Gyógyszerkönyv; Pharmacopœa Hungarica" (Pest, 1871). The text is in Latin and Hungarian on opposite pages. It follows the Austrian Ph. very closely, but has some special features of merit. In 1883 a supplement was published in which, among other things, a series of antiseptic dressings are made officinal.

Belgium.—Previous to 1815, the countries now known as Holland or Netherlands, Belgium, and some adjacent portions, were subject to many political changes. Hence, though there was a "Ph. Belgica" published already in 1659, yet this cannot be considered as a legitimate precursor of the modern works. Various cities of the present kingdom of Belgium published separate Ph., thus: Brussels ("Ph. Bruxellensis," 1639+); Gand ("Antidotarium Gandavense," 1652+); Leyden ("Ph. Leidensis," 1638+); Liège ("Ph. Leodensis," 1741); Lille ("Ph. Lillensis," 1640+); Antwerp ("Ph. Antverpensis," 1661, 1665, 1812). In 1774 the "Ph. Austriaco-Provincialis" was prescribed for use by the Government of Austria, and this was superseded, in 1805, by the "Ph. Batava" (see Netherlands). The first national Ph. proper was published in 1823. In 1854 appeared a new edition under the title "Ph. Belgica Nova," and the last edition which is officially designated as the "Second," appeared in 1885. The text is published both in Latin and French, though the former is declared to be the official version. The titles are arranged alphabetically, and in nomenclature as well as in the treatment of the subjects, the work much resembles the French Ph. It has, however, avoided the numerous errors or blunders with which the latter work is contaminated.

Bolivia has no Ph. of its own. The French and Spanish Ph. are mostly in use.

Brazil is still without a Ph., though attempts have been made to compile one. Aside from the Spanish, Portuguese, and French Ph., which are much in use, the following two works are generally consulted: Chernoviz, "Formulario, ou Guia Medica" (Paris, many editions); Langgaard, "Novo Formulario Medico e Pharmaceutico" (Rio de Janeiro).

British Empire.—Up to the year 1864, England, Scotland, and Ireland possessed, each, its own Ph. That for England was first published in 1618, under the title "Ph. Londinensis," by the London College of Physicians. It was several times reprinted with slight alterations, until 1650, when its second revision was published. The succeeding revisions appeared in 1677 (III.); 1721 (IV.; in this edition vegetable drugs were for the first time defined as to origin); 1746 (V.; in this edition great advance was made; many of the old complicated formulas were curtailed and shorn of useless material); 1788 (VI.); 1809 (VII.); 1824 (VIII.); 1836 (IX.); and 1851 (X.). Besides the official editions, the text was incorporated into many other works, such as commentaries or dispensatories, either written for it alone, or for all the British Pharmacopœias together. It was also translated into various other languages, even into Hindustani (Calcutta, 1824).

The first Ph. for Scotland was published by the Edinburgh College of Physicians in 1699, under the title "Pharmacopœia Collegii Regii Medicorum Edinburgensis." The subsequent editions or re-issues were very numerous.

The first Ph. for Ireland appeared at Dublin in 1807, under the title "Pharmacopœia Collegii Medicorum Regis et Reginæ in Hibernia." Previously, however, a specimen Pharmacopœia had been prepared and circulated already in 1794, and again in 1805. The Dublin Ph. was revised in 1826 and 1850.

The disadvantage of having three different pharmacopœias legalized in closely connected countries possessing one language, was early recognized, but political considerations prevented a fusion, until the Medical Act of 1858 was passed, which provided for the compilation of a joint work. After much labor and delay, the first "British Ph." appeared in 1864, but the work was found to suffer from numerous defects, chiefly due to the difficulty encountered in reconciling the different usages in pharmacy and in prescriptions existing in the three countries. It was, therefore, revised by the General Medical Council, and a new edition issued in 1867. A supplement containing thirty-four additions was published in 1874. The last revision, conducted under the direction of the Council by Professors Attfield, Redwood, and Bentley, appeared in 1885. This edition having had the advantage of being able to profit from the preceding appearance of new editions of the U. S., German, and French Ph., and from the large amount of pharmacopœial contributions available in the current literature, shows great advance over its predecessor; yet it seems that the work has not been quite as satisfactory to the medical and pharmaceutical public as might have been expected, partly for this reason, probably—because the editors were not empowered to avail themselves of the assistance and experience of other experts, more familiar with certain matters than themselves. After the work had appeared, a supplement was issued in which some of the principal errors were corrected. The lesson which has thus been learned has not been forgotten, for provision has been made for a more thorough and systematic revision, by the appointment of Professor Attfield as Permanent Reporter on the Revision of the Ph.

One of the dependencies of Great Britain, viz., *India* has a Ph. of its own. In 1842, Dr. W. B. O'Shaughnessy issued, by order of Government (under the authority of the East India Company), "The Bengal Dispensatory" (Calcutta), as a precursor to "The Bengal Pharmacopœia and General Conspectus of Medicinal Plants," which he published at Calcutta, in 1844. In 1868, a "Pharmacopœia of India" was published at the same place by Dr. Ed. J. Waring, under authority of the Secretary of State for India. This is now in force, alongside of the new British Ph. The main object of issuing a separate Ph. for India, was to officially encourage and authorize the employment of East Indian drugs, among which are many possessing very valuable properties. A most useful companion to this work is the "Supplement to the Ph. of India," by Moodeen Sheriff, pub-

lished by order of the Government of Madras, in 1869. This work contains synonyms of the pharmacopœial articles in fourteen languages. A revision of the Ph. of India is in contemplation.

Central American States.—These States have no Ph. Various authorities are followed, mostly perhaps the Spanish and French Ph., in some places also the U. S. and British.

Chili.—The first Chilian Ph. appeared in 1886, under the title, "Farmacopea Chilena, obra premiada por la Facultad de Medicina de Chile y mandada adoptar por el Supremo Gobierno de la Republica como Farmacopea Nacional. Por Adolfo Murillo, médico, Carlos Middleton, farmacéutico" (8vo, Leipzig, 1886). The text is in Spanish, synonyms of the titles being given in Latin. It bears much resemblance to the last French Ph., but is free from most of the errors contained in the latter. Its intrinsic merits should render it the basis for other South American pharmacopœias.

China.—China has, of course, no Pharmacopœia in our sense of the word. But there are numerous native works treating of the selection and preparation of substances for medical use. The best known and most extensive work on this and kindred subjects is the "Pen tsao kung mu" (in Japanese: Honzo-ko moku) of Li-shi-chin, written about 1560 A.D., being an encyclopædia compiled from about 1,000 different native authors, on some 1,900 drugs from the three kingdoms of nature, explaining also their medical properties, and giving nearly 12,000 formulas. (A synopsis of the contents is given by Bretschneider, "Botanicon Sinicum," London, 1882, pp. 49–69.)

Denmark.—In 1658 the "Dispensatorium Hafniense" was published at Copenhagen, and this was several times reprinted. The first official Pharmacopœia appeared in 1772, the second in 1805, and the third in 1830. The latter was, however, counted as the *first* work really deserving this name; hence the next and last edition, published in 1868, was designated as "editio secunda." Supplements to it appeared in 1874, 1876, and 1886. The text is in Latin, and the chemical nomenclature is that of Berzelius. It contains about 650 titles, without the supplements. Much similarity exists between the Danish, Norwegian, and Swedish Pharmacopœias, which is the result of deliberate design, as these countries are closely allied in customs, traditions, and language. A separate Military Ph. is in existence.

Ecuador has no Pharmacopœia, but the last London Ph., as well as the Brit., U. S., and French Ph., are mostly followed.

France.—In 1353 King John, "the good," commanded the apothecaries to follow the "Antidotarium" of Nicolaus Præpositus. Strict regulations regarding the practice of pharmacy were made in 1536, and frequently afterward. As early as 1546 a "Ph. Lugdunensis" was published at Lyons, which was several times reprinted. A French "Paraphrase sur la Pharmacopée" was issued by Briçon Bauderon, of Mascon, in 1588+. In 1590, the Paris Faculty of Medicine was directed to prepare a dispensatory; but, as nothing was done, Parliament, in 1597, ordered twelve members of the Faculty, designated by name, to prepare the work. The order was, however, not obeyed. Several French cities early possessed Pharmacopœias of their own, thus: Burdigal ("Ph. Burdigalensis," 1643); Strasburg ("Ph. Argentoratensis," 1725+); Toulouse ("Codex Medicamentarius, seu Ph. Tolosana," 1648, 1695); Valenciennes ("Ph. Valentianensis," 1651). A new "Pharmacopée de Lyon" was also published by Vitet in 1788. The last-named work, to a slight extent, answered the purpose of a revised edition of the last Paris Pharmacopœia in some localities. In 1637 the "Ph. Parisina" appeared as a precursor to the first official Paris Pharmacopœia, which was issued in 1639 under the title "Codex Medicamentarius, seu Ph. Parisiensis, in lucem edita a Ph. Harduino." Revisions of this appeared in 1645, 1732, 1748, 1758. No further revision appeared then until, after an interval of sixty years, a national Pharmacopœia was issued in 1818, under the title: "Codex Medicamentarius, seu Ph. Gallica," the text being in Latin. In the second and following editions the French language was chosen for the text, only the synonyms of the titles being given in Latin. These editions appeared in 1827 (II.), 1839 (III.), 1866 (IV.), and 1884 (V.). The last revision was a very unsatisfactory one, as the revisers do not seem to have paid attention either to the other new Pharmacopœias (U. S. and Germ.) which had appeared a short time previously, or to the copious literature relating to pharmacopœial improvements. Immediately after the work had been issued very numerous errors were discovered in it, so that the government was compelled to make a fresh issue, in which one hundred and thirty-two alterations were incorporated; and a special pamphlet entitled "Erratum," was shortly afterward sent out, in which eighty-three additional changes were directed to be made. But this list of errata is not only itself not free from errors, but is far from being complete. In connection with the French Ph. should be mentioned the well-known work of Dervault, "L'Officine," constituting an exhaustive commentary and supplement to the Pharmacopœia. In some foreign countries, which do not possess a Pharmacopœia of their own, this work is frequently followed as the principal authority, being used either in the original French or in Spanish translation.

Germany.—The first official formulary published in Germany was that of Valerius Cordus, published after his death by the city of Nuremberg, in 1546, under the title, "Pharmacorum omnium quæ quidem in usu sunt conficiendorum ratio; vulgo vocant Dispensatorium pharmacopolarum" (for full title and details see *Amer. Drugg.*, 1887, 21). The work contains but few simples, but chiefly formulas of preparations taken from Greek, Roman, and Arabic medical writers, particularly Dioscorides, Galenus, Rhazes, Avicenna, Mesue, and Nicolaus Præpositus. All the preparations are of a Galenical character, comprising articles taken from the three kingdoms of nature. The titles of the preparations are usually chosen from the name of one of the ingredients; many of the titles had been in use before, others were newly coined. Some of these have continued to the present day, though in some cases the composition has utterly ceased to correspond to the title. Cordus's dispensatory was often reprinted, both at Nuremberg and elsewhere. There is a Paris edition of 1548, three of Lyons (1552, '59, '99), two of Venice (1556, '63), etc. The first edition contained neither tinctures, nor extracts, nor chemicals. Distillation is used to prepare certain ethereal oils. In the Nuremberg edition of 1592, the text was revised and augmented, among others by several American drugs (sassafras, sarsaparilla, and tobacco). Chemicals also first appear in this edition—namely, native salts, such as alum, borax, saltpetre, etc., and certain artificial salts prepared from the ashes of plants and other substances. The use of the metallic salts introduced by Paracelsus (turpeth mineral, calomel, etc.) is specially prohibited. Extracts and distilled waters are added. In the next revision of 1598, large additions and changes were made. Among the additions are Brasil and guaiac wood, Mechoacan root, and many animal preparations. Also mineral substances, such as white arsenic, realgar, orpiment, corrosive sublimate, calomel, and oil of vitriol were admitted. The next edition, 1612, was not much changed and remained in force until 1666, when the fifth and last revision was published. In this the materia medica was much altered, and, to a large extent, for the worse, many kinds of stercus and other nauseous preparations being introduced. On the other hand, there were added cinchona, jalap, balsams of Peru and Tolu, tinctures, and many new chemical salts under the then prevailing alchemistic nomenclature; also, the well-known "pilulæ perpetuæ," and the drinking-cups of antimony. Aside from organic proximate principles and other chemicals, which were unknown at that time in consequence of the insufficiency of chemical knowledge, the last edition of Cordus's work contained nearly all classes of preparations which we still make use of. It certainly formed the basis upon which subsequent European Pharmacopœias were constructed. In 1538 the physicians of Augsburg prepared a sort of Pharmacopœia under the title, "Conclusiones et Propositiones Universam Medicinam Com-

plectentes," containing formulas which were afterward generally followed. Augsburg was at that time the chief entrepôt of the German trade with Italy and the Levant; hence many of the imported medicines came by way of Augsburg. In 1564 the first edition of the "Ph. Augustana" was published, which was often revised, and Cologne followed the example in 1565, by the publication of a "Dispensatorium" which was replaced by a "Ph. Coloniensis" in 1627.

The disunited condition of the countries inhabited by the German nation up to within recent times, has been the means of bringing into the world a large number of independent Pharmacopœias, for separate cities or principalities, of which a list follows here: Stralsund ("Actuarium Ph. Stralsundensis," 1645); Quedlinburg ("Quedlinburgensis Officina Pharmaceutica," 1665); Brandenburg ("Dispensatorium Brandenburgicum," 1698, forming the starting-point of the later Prussian Pharmacopœias); Hanover ("Ph. Hanoverana," 1706; last edition, 1861); Hamburg ("Dispensatorium Hamburgense," 1716; "Codex Hamburgensis," 1835, 1845); Ratisbon ("Disp. Pharm. Ratisbonense," 1727; Munster ("Disp. Monasteriense," 1739); Wurtemberg (Ph. Wirtembergica," 1741; last edition, 1847); the Palatinate ("Disp. Med.-Pharm.," 1764); Brunswick (Disp. Pharm. Brunsvicense," 1777); Wurzburg ("Pharm. Herbipolitana," 1778; last edition, 1796); Westphalia (Disp. Westphalicum," being identical with Piderit's "Pharmacia Rationalis" (see under Saxony), 1779); Fulda ("Disp. Fuldense," 1787); Bremen ("Pharm. in usum . . . Bremensis," 1792); Schaumburg-Lippe ("Disp. Lippiacum," 1792); Oldenburg ("Ph. Oldenburgensis," 1801); Hessen ("Disp. Electorale Hassiacum," 1806; "Pharm. Hassiae," 1827, 1860); Erfurt ("Neue Pharmakopoe" . . . von Trommsdorff, 1808, was introduced by order of the French in place of the "Prussian Ph."); Saxony (in 1806, Piderit's "Pharmacia Racionalis," Cassel, 1779–81 was prescribed as Ph. In 1820 appeared "Ph. Saxonica," the last edition in 1837); Bavaria ("Ph. Bavarica," 1822, last edition in 1859); Sleswig-Holstein ("Ph. Slesvico-Holsatica," 1831); Baden ("Ph. Badensis," 1841).

Many of these were revised and republished a number of times.

The most important of all former German Ph. has undoubtedly been the Prussian. This had its beginning in the "Brandenburg Dispensatory" of 1698, the last revision of which, or the sixth edition, appeared in 1781. In 1799, the first "Ph. Borussica," was published. The next editions came out in 1801 (II.), 1813 (III.), 1827 (IV.), 1829 (V.), 1846 (VI.; this is considered to have been the best Ph. of its time); 1862 (VII.). Four editions of a separate Military Ph. were also published, the last one in 1868.

The problem of a united Pharmacopœia for all German States had often been agitated, but in vain. In 1861 Dr. Walz proposed the publication of a German Pharmacopœia by private enterprise, which was to be recommended for adoption, or at least as a pattern, to the different German States. The work appeared in 1865, under the title "Pharmacopœa Germaniæ." Among the compilers were two Austrians, as it was at the time believed that the work might be accepted by all German-speaking peoples. But the war of 1866 rendered the project, as originally conceived, nugatory. A second edition was published in 1867, in which the Austrian members were omitted. Yet even this failed of recognition. It was only after the establishment of the German Empire that the desired object was attained. In 1872 was issued the first "Ph. Germanica," superseding all the separate Ph. at that time in force in German countries. Some amendments to this were published in 1873. When the time for a new revision arrived the Government invited all medical and pharmaceutical bodies and prominent individuals in both professions to submit proposals regarding the new revision. Contributions were received from a large number of sources, and these were printed by Government in a large folio volume of six hundred and ninety-one pages. The Committee of Revision, consisting of thirty-three members, under the presidency of Dr. Struck, held only a few personal meetings, but the work of the commission was much facilitated by the fact that the Government from time to time issued printed circulars among the members. The final draft of the work having been first printed in German (fol.), the work appeared in its official Latin garb in 1882, and went into force on January 1, 1883. An official German translation was likewise published. And an English translation, by C. L. Lochman, has appeared at New York in 1884.

At the present time the work is being subjected to a critical revision by a standing committee, appointed by the German Pharmaceutical Association, and steps are being taken to have an official permanent commission appointed.

The influence of the German Ph. extends far beyond the geographical limits of the German Empire. Outside of the U. S. Ph., there is probably no other, even not excepting the British, which is so frequently drawn upon by prescribers in this country.

Greece.—The first Greek Ph. was published in Athens under King Otto I., in 1837, under the title, "Ἑλληνικὴ φαρμακοποιία . . . παρὰ Ἰωάννου Βούρου. Ξαυερίου Λανδερέρου, Ἰωσὴφ Σαρτορίου," etc. ("Greek Pharmacopœia . . . by Johannes Bouros, Xaverios Landerer, Joseph Sartorius," etc.). It was based on the French, Bavarian, and various other German Pharmacopœias existing at that time. The text is in Latin and modern Greek, side by side. Synonyms are given in Italian, French, English, German, and Turkish, wherever possible, but among them are many mistakes. In 1868, Professor Landerer had the work reprinted, with a supplement (παράρτημα) of the newer preparations, an etymological glossary, and a table of antidotes. This reprint was officially recognized by Government. In general it must be said that the work is very far behind the time.

Hayti has no Pharmacopœia of its own. The French Codex is mostly followed; also the German, British, and U. S. Ph.

Hawaiian Islands.—The U. S. Ph. is generally followed. Occasionally also others.

Italy.—A Commission for the publication of a National Pharmacopœia was appointed years ago, and though the draft, elaborated under the presidency of Professor Canizzaro, was reported ready in 1884, it has not yet been issued, though it is reported to be in the press at the present time. Meanwhile, different portions of the country use such works as are prescribed by their local authorities. The Italian army uses the Sardinian Ph. of 1853.

Italy was the first country in Europe in which an official Pharmacopœia was published. This was the "Antidotarium Florentinum," first published at Florence in 1498. Other similar works appeared at Mantua ("Antidotarium Mantuanum," Venice, 1559); Bergamo ("Ph. Bergomensis," 1580); Venice ("Ph. Veneta," 1617; "Codice pharmaceutico," 1790); Messina ("Ph. Messanensis," 1629); Naples ("Antidotarium Neapolitanum," 1649); Turin ("Ph. Turinensis," 1736); Sardinia ("Ph. Sardoa," 1773; the last edition, "Farmacopea per gli Stati Sardi," of 1853 is still in force); Bologna ("Antidotarium Coll. Med. Bononiensis, 1783); Genoa ("Formulario farm.," 1791); Ferrara ("Farm. Ferrarese," by Campana, 1799, etc.); Parma ("Ph. Parmensis," 1823; another edition of this appeared in 1839 for Piacenza, Parma, and Modena together). The Church States, Tuscany, Lucca, and many other Italian provinces follow a dispensatory published by Orosi, under the title "Farmacologia teorica e practica ovvero Farmacopea Italiana." Lombardy and Venice use the Austrian Ph.; Naples uses, besides other works, the "Ricettario farm. Napolitano, 1859. Throughout Italy a new work by Ruata, entitled "Farmacopea Nazionale e Generale, Materia Medica e Terapia" (Verona and Padova, 1883) is now frequently employed.

Japan has been engaged in the preparation of a national Pharmacopœia since 1880, a commission of twenty-one members having been appointed under the presidency of Mr. Hosokawa, among whom were several Europeans

in the service of the Japanese Government (such as Professor Eijkman, Dr. Langgaard, Dr. Von der Heyden, the late Dr. Geerts, etc.). The work appeared in August, 1886, under the title: "On yaku zuki Nippon yaku kiyoku ho." It forms an 8vo volume of nearly 400 pages, the text being in Japanese. After an introduction and preface follows the Pharmacopœia proper, comprising four hundred and seventy-five titles, and this is followed by general directions regarding the keeping of certain drugs and preparations, lists of reagents and volumetric solutions, lists of articles always to be kept on hand, list of separanda, maximum doses, tables of specific gravity and of elements, a Japanese and Latin index, list of errata, table of doses for adults and children, and another list of errata. The original draft was made in German, but the Japanese will remain the official text, and an official Latin translation will also be published. The scientific chemical, botanical, and zoölogical terms are given in Latin, in Roman characters, with Japanese transliteration. In the treatment of the subject, the U. S., British, and German Ph. have been mostly followed, but the text shows also independent and careful work on the part of the compilers. The sign ▽, placed under an unusual quantity of a powerful remedy, is to be used by prescribers for the same purpose as the exclamation sign (!) in European practice, viz., as an evidence that the prescriber intentionally ordered a large dose.

Liberia.—The U. S. and British Ph. are usually followed.

Mexico.—The Pharmaceutical Society of Mexico, in 1874, published a Pharmacopœia which was officially recognized by Government. It was one of the best Pharmacopœias of its time. In 1884, a second edition was issued by the same Society, the text of which was already completed at the close of 1881. Its title is "Nueva Farmacopea Mexicana de la Sociedad Farmacéutica de Mexico." It presents among other special features a very copious Materia Medica, paying particular attention to native products. The text is in Spanish in two columns. In general the work rather corresponds to what we would call a dispensatory, as it treats also of the medical properties and uses of the several drugs and preparations, and covers a good deal more ground than is usual for a pharmacopœia. It is a very carefully prepared and meritorious work.

Netherlands.—The frequent political changes in the Low Countries were not without influence upon the existence or validity of its Pharmacopœias. Among the earlier works of this kind which may be mentioned here are the following, in cities now belonging to the Netherlands: Amsterdam ("Ph. Amstelodamensis," 1636; last edition, 1792, see below); The Hague ("Ph. Hagana," 1652; last edition, 1758); Utrecht ("Ph. Ultrajectana," 1656; last edition, 1749); Louvain ("Ph. Lovardensis," 1687; last, 1745); Haarlem ("Ph. Harlemensis," 1693; last, 1741); Dort ("Ph. Dordracena," 1708; last, 1766); Rotterdam ("Ph. Roterodamensis," 1709; last, 1835); Alcmar ("Ph. Alcmariensis," 1723); Groningen ("Ph. Groningana," 1724, '30). At one time the Netherlands belonged to Austria, hence the "Ph. Austriaco-Provincialis" was made official and a Dutch translation of this was published in 1781. After the establishment of the Batavian republic (1795–1806) a commission was appointed to draft a Pharmacopœia. This was completed and published in 1805 under the title "Ph. Batava," and was a work of great merit, being by far the best of its time. This work has been extended and commented upon by Niemann (1811, second edition, 1824) in an excellent manner. In 1851 appeared the first "Ph. Neerlandica," the text being both in Latin and Dutch. It had much resemblance to the French Codex. A revised edition, both in Latin and in Dutch, appeared in 1871, the Latin version being, as in the first edition, the official text. It contains six hundred and fifty-five titles. A revision of the work is in contemplation.

Norway did not possess a Pharmacopœia of its own until 1854, the Swedish Ph. being used in the country up to that time. The "Ph. Norwegica" was revised in 1870, and this second edition was reprinted with additions in 1879. It contains some five hundred and ten titles. The text is in Latin. It much resembles the Swedish and Danish Ph., but the influence of the German Ph. is clearly perceptible.

Paraguay.—The French, Spanish, and occasionally other Ph., are usually consulted.

Peru.—The French, Spanish, U. S., and British Ph. are usually drawn upon.

Portugal.—In 1704, Caetano de Santo Antonio published a "Pharmacopea Lusitana Galénica" at Coimbra. This was republished at Lisbon (as "Ph. Lusitana," or, "Ph. Ulissiponense") in 1716, and twice reprinted. In 1785 appeared de Poiva's "Farmacopea Lisbonense." The first official Ph. was published by Dr. Tavares in 1794, under the title "Farmacopeia Geral para o Reino e Dominios de Portugal." In 1825 this was supplanted by the "Ph. Lusitana," and this was followed in 1838 by the "Codigo Pharmaceutico Lusitano" (revised 1858). Finally a new "Pharmacopêa Portugueza" was issued in 1876. This is a very good work, prepared with care and judgment. The text is in Portuguese, except the synonyms of titles, which are in Latin. It has been shorn of the obsolete rubbish of the therapeutics of former times.

Roumania issued a Ph. in 1861, under the title "Pharmacopœa Romana." A second edition, revised, appeared in 1874. The text throughout is in Roumanian, without Latin synonyms. It bears some resemblance to the Austrian Ph., but has some distinctive features of its own.

Russia.—Up to the year 1866, Russia had no official national Pharmacopœia, except one for the army which was first issued in 1765. In 1779 a revised and much improved edition of the latter appeared, under the title "Ph. Castrensis Rossica." This was followed in 1789 by a special Pharmacopœia for the navy ("Ph. Navalis," last revised in 1869). Both of these were superseded in 1808 by the "Ph. Castrensis Ruthenica," edited by Wylie, of Moskow. This was several times revised, last in 1866. A civil Pharmacopœia appeared as early as 1778 at St. Petersburg (reprinted in 1782), under the title of "Ph. Rossica," and a second edition in 1798 (reprinted 1803); but these were not officially recognized, the pharmacists being compelled to consult almost every prominent European Pharmacopœia when putting up prescriptions. That which was most followed, generally, was the "Ph. Borussica." In 1866 the first official civil Ph. was issued. This was followed by new editions in 1871 and 1880. The title is "Rossiïskaya Pharmakopeya," etc. (translated "Russian Pharmacopœia, edited by the Medical Council in the Department of the Interior, by order of His Imperial Majesty," etc.). The text of the work is in Russian; the main titles and synonyms, however, and the names of the ingredients entering into any preparation, are in Latin. Great care has been bestowed upon it; the best features of the German Ph. (first edition), together with improvements proposed by critics, being incorporated into it. The number of titles is one thousand and four. A special Ph. for the use of the Imperial court was published in 1874. Hence there are four Pharmacopœias in existence—the military, the naval, the civil, and the court Ph. All of these have Russian text with Latin titles. The military Ph. is, in some respects, a sort of dispensatory, as it goes more into detail.

A separate Pharmacopœia was published for Poland, in Warsaw, in 1817, under the title "Ph. Regni Poloniæ," but this does not seem to have long remained in force. On the other hand, Finland published a Pharmacopœia of its own ("Ph. Fennica") in 1819 (at Abo). Later editions of this appeared at Helsingfors in 1850 (II.), 1863 (III.), and 1885 (IV.). The text of this is in Latin. It is closely allied to the several Scandinavian Pharmacopœias, and, in certain features, still more closely to the last German Pharmacopœia. In extent, it is one of the smallest, comprising only about four hundred articles.

Spain.—Previous to the appearance of a national work, local Pharmacopœias had been in existence in the following cities: Salamanca ("Ph. Salamanca," by J. Bravo, 1588); Barcelona ("Ph. Catalana," 1686); Almeria ("Ph. Almeriana," 1724); Saragossa and Valencia ("Officina Medicamentorum," 1601, 1698, 1739); Madrid ("Ph.

Matritensis," 1729+). In 1521 was published at Madrid the "Examen Apothecariorum," composed in 1497 by Pedro Benedicto Mateo, which has been found by Mallaina to be a veritable Pharmacopœia. The first national Pharmacopœia ("Ph. Hispana") appeared in 1794. This and the next three editions, viz., of 1798, 1803, and 1817, were written in Latin. The fifth (1865) and sixth editions (1884) are in Spanish with Latin synonyms of the titles. The "Farmacopea Oficial Española" appears to have made the least progress of any. Even the last edition, here and there, betrays an adherence to unscientific, empirical, or obsolete remedies and methods. Besides, it bears internal evidence of the influence of the new French Codex. In the number of articles, of which it contains nearly one thousand seven hundred, it is only exceeded by the last-mentioned work.

Attempts have been made to prepare a separate Pharmacopœia for *Cuba*, but no tangible results have been reached thus far.

Sweden.—A "Ph. Holmiensis" was published at Stockholm in 1686. The first work, bearing the title "Ph. Suecica," appeared in 1705, but without special authority. The first official Pharmacopœia appeared in 1775, and the succeeding editions in 1779 (II.); 1784 (III.); 1790 (IV.); 1817 (V.; in this edition the chemical portion was edited by Berzelius, and the botanical and zoological by Swartz; it was the most advanced and perfect Pharmacopœia of its time); 1845 (VI.), and 1869 (VII., with supplement of 1879). The last edition has been several times reprinted with amendments. It has much resemblance to the Danish and Norwegian (see under Denmark). The text is in Latin, and the number of titles is six hundred and seventy-seven.

Switzerland.—A "Ph. Helveticorum" was published at Geneva in 1677. In 1684 there appeared in the same city an edition of Charas' "Pharmacopœa Regia Galenica et Chymica," which was followed as authority for a long time. The Basle Medical Society, in 1771, published a "Ph. Helvetica" (containing an introduction by A. de Haller). A "Ph. Genevensis" appeared in 1780, and was reprinted several times afterward. In 1852 an elaborate draft of a Pharmacopœia for the Canton of Berne was published at Berne under the title "Pharmacopœæ Bernensis Tentamen." This may be regarded as the precursor of the "Ph. Helvetica," published in 1865 at Schaffhausen, by the Swiss Pharmaceutical Society. The latter work has been recognized by law in most of the Cantons, but not in all. A second edition appeared in 1872, and a large supplement in 1876. The text is in Latin. It has much in common with the German Pharmacopœia (I.) and its immediate German predecessors. The Canton of Tessin has a Pharmacopœia of its own, published in 1848; and Geneva uses the French Codex.

Turkey.—The Imperial Medical School at Constantinople has enjoined the use of the French Codex. Other foreign Pharmacopœias, however, are also in use.

Uruguay.—The French, Spanish, and occasionally other Pharmacopœias are followed.

Venezuela.—Most in use are the French and Spanish Ph. The Medical Faculty at Carácas has taken initiatory steps to prepare a national Pharmacopœia.

United States.—The first Pharmacopœia in the United States was published at Philadelphia, for the use of the Military Hospital of the U. S. Army, located at Lititz, Lancaster County, Pa., in 1778, under the title, "Pharmacopœia simpliciorum et efficaciorum in usum nosocomii militaris ad exercitum fœderatarum Americæ civitatum pertinentis; hodiernæ nostræ inopiæ rerumque angustiis, feroci hostium sævitiæ, belloque crudeli ex inopinato patriæ nostræ illato debitis, maxime accommodata" ("Pharmacopœia of the more simple and efficacious [preparations] for the use of the Military Hospital of the Army of the U. S. of America; specially adapted to our present poverty and distress, due to the ferocious cruelty of the enemy and to the bloody war unexpectedly brought upon our fatherland"). Only one copy of this edition is known to exist, which is in the Surgeon-General's Office at Washington. Of a second edition, there appears to be likewise only one copy known (see *Am. Journ. Pharm.*, 1884, 483). This was issued in 1781. Upon the title appears the name of Dr. William Brown, as author. It is entirely in Latin, in 32 pages. It contains 84 internal and 16 external remedies. Previous to the year 1820, various European Pharmacopœias, chiefly those of London, Edinburgh, and Dublin, were used in the United States, though the want of a national Pharmacopœia was, to some extent, filled by Coxe's "American Dispensatory" (first ed., Philad., 1806+), and Thacher's "American New Dispensatory" (first ed., Boston, 1810+). In 1808, the "Ph. of the Massachusetts Medical Society" was published at Boston, and in 1816, the "Ph. of the New York Hospital," at New York. The first impetus to a national Pharmacopœia was given in 1817, by Dr. Lyman Spaulding, in a plan laid before the Medical Society of the County of New York. (For details of the history of the "Ph. of the United States of America," consult the latter work, sixth edition, New York, 1882, pp. v.–xiii.) The first convention for the formation of a national Pharmacopœia assembled at Washington, on January 1, 1820, at which time the several drafts previously prepared by the several District Conventions were consolidated and revised. The finished work was published at Boston, on December 15, 1820, both in Latin and English. A second edition appeared in 1828. Before adjourning, the Convention provided for a future revision of the work, by arranging for the call of a convention in 1830. Owing to a misunderstanding, however, two separate conventions were held in this year, one meeting at New York, and the other at Washington, and two separate Pharmacopœias resulted from this, one being published at New York, in 1830, the other at Philadelphia, in 1831. Fortunately, the bodies who had met at New York subsequently abandoned the plan of continuing a separate revision in the future, and in 1840, the third general convention assembled again at Washington. The Committee of Revision appointed at this convention was authorized to request the co-operation of the colleges of pharmacy, and this resulted in the contribution of much valuable material. The new revision was published in 1842, the text being for the first time only in English, the Latin being restricted to the titles and synonyms. At the next convention, in 1850, the incorporated colleges of pharmacy were for the first time invited to participate in the deliberations. Previous to this, only incorporated medical societies had been invited to send delegates. The fourth edition of the work appeared in 1851, and a second edition of this in 1855. The next two conventions met at the appointed time, in 1860 and 1870, and the fifth and sixth editions of the Pharmacopœia were issued in 1863 and 1873, respectively. Several years before the next succeeding convention (in 1880), a very lively interest was awakened in the proposed new revision of the work, and several plans were advanced, looking toward a radical change in the manner of revising and controlling the revision of the Pharmacopœia. A large amount of preliminary work was also bestowed, principally on the part of the American Pharmaceutical Association, upon the plan and contents of the next edition. The convention which assembled at Washington, in 1880, was the most representative of any that had so far been held, and after a general plan of revision had been adopted, a Committee of Revision and Publication was appointed, consisting of twenty-five members, residing in various parts of the United States. This Committee has made a detailed report of its proceedings in the preface to its work, which appeared toward the end of 1882 (see "U. S. Ph.," 1882, pp. xxvii.–xxxiii.). The title-page designates this as the "Sixth Decennial Revision;" consequently, this is the *seventh* edition of the work. In this revision radical changes were made, the intention being to render the work as independent of commentaries as was possible. The arrangement is alphabetical throughout, all crude drugs and chemicals are defined and accompanied by descriptions, or by tests of identity and purity. Actual weights and measures are replaced by a system of parts by weight, except in the case of fluid extracts. Many obsolete articles were dropped, and many new ones admitted, the total number of accepted titles being 997. The general verdict of all com-

petent critics, both at home and abroad, has been that this is one of the best Pharmacopœias ever issued, and that it does not even suffer by comparison with works that have appeared later. It has long been felt that the Pharmacopœia contains a considerable number of preparations which are not frequently prescribed, and are only retained for the reason that, if called for at all, their uniform composition may be insured. There is a movement on foot, which it is hoped will relieve the Pharmacopœia of the task of providing a standard for such preparations. The American Pharmaceutical Association is engaged in the compilation of a "National Formulary of Unofficial Preparations" (to be subject to the approval of, and expected to receive the support of, the medical profession), which is primarily designed to establish uniform formulas for any compound used in legitimate pharmacy or prescribed by physicians, and for which there is no recognized official standard. This formulary may eventually be made the repository of all such pharmacopœial articles as are no longer deemed of sufficient importance to be included in the official list. The next convention for revising the U. S. Ph. will assemble at Washington on the first Wednesday of May, 1890.

General Pharmacopœias.—Many works have been published, designed to comprise the text of all, or at least the most, prominent Pharmacopœias. Among the earlier authors of such works are Lemery, Charas, Spielmann, Swediaur, Quincy, Brugnatelli, etc. Of more recent works the following deserve special mention: A. J. Jourdan, "Ph. Universelle" (Paris, 1828, second, ed. 1840); P. L. Geiger, "Ph. Universalis" (Heidelberg, 1835–45); B. Hirsch, "Universal-Pharmakopöe" (Leipzig, 1885, vol. i.).

International Pharmacopœias.—Many years ago efforts began to be made to bring about greater harmony in the different Pharmacopœias, and the proposition was finally made to inaugurate an International Pharmacopœia. Opinions differed greatly for a long time, not only as to whether the plan was feasible at all, but also in regard to details. Steps were finally taken to have a draft of the work prepared, but national jealousy on several occasions rendered its acceptance impossible. It was not to be expected that each civilized nation would abandon its own Pharmacopœia, specially adapted to the habits of its own people and its own domestic resources, for one elaborated without regard to such considerations, and possibly introducing unfamiliar preparations or changing the strength of such as were in common use. The utmost that could be expected was that the different nations, whenever revising their own Pharmacopœias, would gradually approximate such preparations as were regarded worthy of international regulation to the proposed standard. Another hope which was expressed was this, that the International Pharmacopœia might be used and followed as an *independent* work in different countries in this way, that prescribers would designate preparations contained in it in their prescriptions. At the last International Pharmaceutical Congress, held at Brussels in 1886, the draft of an international Pharmacopœia was presented by the President of the International Commission, Baron A. von Waldheim, of Vienna. Yet, in its preparation the other members of the commission had not been sufficiently consulted, and it is, therefore, not probable that the draft will be accepted in its present form.

While an international Pharmacopœia, in the sense in which it was first contemplated, is not likely ever to be established, it is, on the other hand, possible, by international conventions, to establish uniform *methods* for revising the several Pharmacopœias, so as to bring about, at least gradually, an equalization in the strength of the potent remedies and their preparations.

General Remarks.—A Pharmacopœia is supposed to represent the broad results of therapeutic investigations and observations accepted by, or acceptable to, the medical profession at large in the country for which it is written. In general, therefore, it should not introduce insufficiently tried new remedial substances or methods, but should accept only such as have, by matured and careful study, been found worthy of recognition. Exceptions to this rule are, however, admissible where it can be clearly demonstrated that an innovation will be an improvement. As an instance of such exception may be quoted the introduction of *abstracts* in the last U. S. Ph., these being merely dry extracts, brought into a definite proportion with the crude drug from which they are prepared (2 parts of abstract = 1 part of drug). In most countries the Pharmacopœia is recognized by law as the authority for deciding questions relating to the identity, quality, purity, or strength of all substances for which it provides a norm. In the United States it is thus recognized expressly by a number of States, as well as by the general Government for the public service. In most European countries the official text of the Pharmacopœia is written in Latin, as it is argued that this will insure better mutual understanding as well as a smaller risk of ambiguity in expression than if the vernacular were used. This argument, however, is becoming less valid in proportion as the rapid progress in chemistry and other sciences renders it constantly necessary to coin new words for expressing terms or methods. No objection, however, can be advanced against a Latin nomenclature of pharmacopœial titles, as this will insure uniformity in prescribing and safety in dispensing.

Since the medical and pharmaceutical professions are equally interested in the production of as perfect a work as can be produced, co-operation of the two professions in the revision is absolutely necessary, and the more unhampered the revisers are in the choice of their unofficial assistants, the better will be the result. It has been recognized that a successful periodical revision of a Pharmacopœia is much facilitated by the establishment of a permanent commission to collect and digest all criticisms and proposals for improvement that may be made in the interval between two revisions. The example set by the United States has been followed by several other nations, and the good results of this will become evident in the future. *Charles Rice.*

PHARYNX AND NASAL PHARYNX, SYPHILITIC LESIONS OF THE. The initial lesion of syphilis is occasionally found in the pharynx, and almost invariably on one of the tonsils, the posterior wall being singularly exempt. Sometimes the upper pharynx is the seat of the primary sore, and not a few cases are on record in which the constitutional disease was communicated by means of the Eustachian catheter. The diagnosis of pharyngeal chancre is often a difficult matter, as the characteristics of the primary sore of syphilis are not always well marked, and the diagnosis must be made from the subsequent development of constitutional symptoms.

By far the most common lesions of syphilis in this region are erythema and catarrhal inflammation. A symmetrical arrangement of the erythematous patches is regarded as characteristic of syphilis. There is nothing peculiar to the pharyngeal catarrh of syphilis. In a certain proportion of cases, however, there is a somewhat characteristic discoloration of the mucous membrane, which is suggestive of the disease. When to this is added a tendency to symmetrical patches of cloudy swelling of the epithelium, suspicion of its specific nature may be aroused.

Mucous patches are constant accompaniments of pharyngeal syphilis, and are found most commonly on the soft palate, faucial pillars, and tonsils, rarely on the posterior wall. Varying in size, they appear as whitish or bluish-white elevations—circular, oval, or stratiform—arranged symmetrically on the swollen and hyperæmic mucous membrane. They may be fugitive in nature, disappearing spontaneously in a few weeks, or the epithelium may be cast off and superficial ulcers result. The ulceration from a mucous patch is sometimes so extensive that it may be confounded with the destruction of a tertiary lesion.

The characteristic lesions of the tertiary stage, found in the pharynx, are gummata, diffuse infiltration, and ulceration. I have also met with extensive fibroid de-

generation of the pharyngeal structures similar to that described in the section on Larynx, Trachea, and Bronchi, Syphilis of the (vol. iv.). The mode of development of tertiary ulcers in the pharynx is identical with the manner in which they appear in the larynx (see section referred to). They are found in all portions of the upper and lower pharynx. When seated on the soft and hard palate they show a marked tendency to perforate.

The ravages produced by tertiary syphilitic ulceration of the pharynx are sufficiently familiar. In addition to the perforations already referred to, wide spread destruction of the palate, tonsils, posterior wall, and other parts may occur; caries and necrosis of the posterior wall and pharyngeal vault may complicate the case, or extensive adhesions may form, with partial or complete obliteration of the pharyngeal cavities. Occasionally a perforating ulcer opens a large artery, and alarming hæmorrhage occurs, or the ulcerative process may extend to the brain or spinal cord, with a fatal result.

Of great interest are syphilitic affections of the pharynx in the congenital form of the disease. The fauces, velum, and posterior wall present simply an erythematous efflorescence, or are the seat of lardaceous infiltration. Occasionally the follicles seem to be the starting-point of the disease. They stand out prominently, are filled with a yellowish secretion, and are surrounded by a well-defined inflammatory areola.

Although mucous patches are frequently found on the uvula, tonsils, and faucial pillars, the posterior wall is singularly exempt. Hypertrophy of the tonsils is present in a large proportion of cases. It is simple in character, or the glands may be the seat of lardaceous infiltration. In the latter case they have a square outline, and a uniform, smooth, waxy appearance, in which it is difficult to recognize the mouths of the follicles and lacunæ.

Warty growths are found in the pharynx, both in the acquired and in the congenital form of syphilis.

With deep ulceration of the pharynx stomatitis is commonly associated. The parts are thickened, infiltrated, and present a characteristic albuminous appearance. On this pale ground ramify arborescent wine colored vessels, and here and there small hæmorrhages are seen beneath the mucous membrane. There is often a scarlet line along the gums at the insertion of the teeth, which stands out in striking contrast to the surrounding pallor of the membrane. This is most easily determined by the carious condition of the teeth, and may be analogous to the inflammatory zone which surrounds other syphilitic lesions.

Morell Mackenzie has called attention to the absence of the characteristic notching of the teeth in those in whom the throat is affected. Out of seven cases examined by me in 1879, in reference to this point, there were three in which the notching was not present. In one of these there was a deficiency in the left central upper incisor, giving it a more or less V-shaped appearance, and in another, a roughening of the lateral edge of the lower central incisor of the right side. In the third, the teeth were apparently sound.

It is generally laid down in the text books that deep ulceration of the mouth and pharynx, in congenital syphilis, is very rare; and Mr. Holmes[1] went so far as to say that the affection of the palate so common in syphilis of the adult is "so rare in children that it is doubtful whether the few cases which occur in infants during syphilis may not be mere coincidences." A great deal of confusion prevails concerning this question in consequence of the persistent adherence to the old superstition which regards them as of "scrofulous" origin. It is impossible to exaggerate the rôle of congenital syphilis in the production of the deep destructive pharyngeal ulceration of childhood. The subject is not one of purely pathological interest: under a misconception of its true nature, syphilis, uncontrolled, will lead to destruction and deformity, and influence for evil the future happiness and usefulness of the individual.

Deep ulceration may invade the bucco-pharyngeal cavities at any period of life from the first week up to the age of puberty. Out of thirty cases analyzed with reference to the period of invasion, fourteen occurred within the first year, a proportion of nearly one-half, and of these, ten within the first six months. Whitehead[2] has observed putrid ulceration of the throat in an infant three days old. Of the remaining cases, the majority occurred at a period more or less advanced toward puberty.

It is an accepted fact that syphilis may lie in a state of potential activity within the system for many years after birth. Lying thus quiescent, it seems to await the advent of some physiological epoch to call its phenomena into activity. Thus puberty and its surrounding years is often selected as the chosen period of its outbreak. When the eruption of the disease is thus deferred, it is on the palate and in the pharynx that it most frequently makes its appearance, and deep palato-pharyngeal ulceration often first attracts attention to the existence of a diathesis of which it is the sole pathological expression. Lesions of these structures are found with a peculiar constancy, and upon them syphilis apparently concentrates all its energy and exhibits most of its virulence.

Females are attacked more frequently than males. Out of sixty-nine cases of pharyngeal ulceration forty-one occurred in the female sex.

That the pharyngeal cavity should be frequently attacked is easily understood, when we reflect upon its great vascularity and the irritation to which it is constantly subjected. Ulceration may occur in any situation, but its favorite seat is the palate, and especially the hard palate. When it takes place at the posterior part of the hard palate the tendency is to involve the soft palate and velum, and thence to invade the posterior nares and naso-pharynx. Seated anteriorly it seeks a more direct pathway to the nose by perforation of the bone.

Simultaneous or consecutive ulceration of the palate, pharynx, and nose seems to be characteristic of syphilis.

The next most common seats of ulceration, in the order of their frequency, are the fauces, the naso-pharynx, the posterior pharyngeal wall, the nasal fossæ and septum, the tongue and gums.

A peculiarity of these ulcers, and especially those of the palate, is their centrality of position. They are generally found in the median line of the vault, at the junction of the palatal processes of the superior maxilla, and the areas of destruction on either side are equal and symmetrical.

Often more acute in their development, and advancing with more rapid strides than in the tertiary syphilis of the adult, the special tendency of these ulcerations is to attack the bone and lead to caries and necrosis. Disorganization of the bone occurs in over three-fifths of recorded cases. The great vascularity of the periosteum and medullary membrane in youth, doubtless, invites invasion of the osseous structures. This, however, is contrary to the experience of Colles,[3] who never saw a case; of West,[4] who has seen necrosis only once; of Holmes,[5] who has seen sloughing of the soft palate, but not excavated ulcers or caries of the hard palate; and of Cooper Forster,[6] who has never met with an example in which syphilis had advanced to disease of the bone.

The tendency to necrosis exists at all periods of life; but especially in early youth, at which time it is more destructive and less amenable to treatment. When ulceration occurs on the hard and soft palate, perforation of these structures takes place in very nearly one-third of the cases.

As a rule, the ulcers originate upon the palate or within the pharynx, but they are also consecutive to deep, ulcerating syphilides of the nose and face. Whatever their point of departure, the palate is often the structure upon which the destructive process ultimately descends.

The palate, pharynx, and nose, then, constitute a well-defined territory singularly obnoxious to these ulcerative products, and within whose confines we may best study the development and growth of these degenerate lesions of syphilis.

Ulceration of the tongue occurs in a certain proportion of cases. I have met with it three times in congenital syphilis. In the first case the ulcer was situated on the

right side of the tongue, near its tip; in the second, in the left glosso-epiglottic fossa; while the third followed the breaking down of a large gumma on the upper surface of the tongue near its base.

The ravages of the disease present the typical appearances that are found in the tertiary syphilis of the adult. (For the diagnostic characters of the syphilitic ulcer, its differential diagnosis, the article on Larynx, Trachea, and Bronchi, Syphilis of the, should be consulted.) The appearance of the ulcer will vary to a certain extent with the general condition of the patient. In a badly nourished, cachectic child the granulations may assume a pale, unhealthy, and indolent look, and the red corona may fade into a purplish ring, or even be entirely wanting. But in all there is a strict adherence to the true syphilitic type of ulcer.

As a result of cicatrization, adhesions may form between the velum and the pillars of the fauces, or between the latter and the pharyngeal wall, and there may be stenosis and obliteration of the pharynx and naso-pharynx; in fine, all the sequelæ are found which follow constitutional syphilitic ulceration in these localities.*

The *prognosis* in syphilis of the pharynx is generally good, provided the patient be seen before extensive destruction has taken place. In congenital syphilis it is greatly influenced by the age of the patient; the earlier the pharynx is attacked, the graver the prognosis. Pharyngo-laryngeal ulceration occurring within the first year is almost invariably fatal. Pharyngeal ulceration appearing late, or as a manifestation of "tardy syphilis," yields readily to iodide of potassium, and the topical application of iodoform or the vapor of the iodate of zinc.

The separation of syphilitic ulceration of the pharynx from that of tuberculosis, lupus, lepra, and cancer should be made upon the principles of differential diagnosis laid down in the article on Syphilis of the Larynx. It should not be forgotten, too, that typhoid fever, diphtheria, and other acute systemic disorders may lead to destruction which resembles that of syphilis so closely as to render an appeal to the history of the case imperative. The soft palate and pharynx may also be destroyed by traumatic causes, or be badly scarred from chemical irritants. Sloughing may also occur from poisonous doses of drugs, such as mercury in its various forms.

Treatment should be carried out on the principles already indicated in the section on Syphilis of the Larynx. In my experience the best application to the mucous patch is the solid stick of silver nitrate, while for the tertiary ulcer iodoform may generally be relied upon as a rapid promoter of cicatrization. Adhesions may be divided with the knife or galvano-cautery, but unless serious interference with function is threatened, they had better be left alone. Partial stenosis of the upper and lower pharynx may be treated by systematic dilatation with sounds, by divulsion, or by the use of the cautery or knife. When the stenosis is complete, and the pharynx is filled with dense fibroid tissue, the treatment will depend upon the circumstances of the case and the ingenuity of the surgeon. In cutting through the new-formed tissue in the nasal pharynx, it is always best to previously introduce a catheter or similar contrivance through the nose, upon which to cut as a guide. The results of treatment in this class of cases cannot be said to be brilliant. The tendency to recurring stenosis is great, and the surgeon is fortunate who obtains a satisfactory permanent opening. Delavan, of New York, profiting by the observation of Andrew H. Smith—that the eschar after the use of monochloracetic acid remains attached until cicatrization has taken place beneath it,—in a case of adherent velum, divided the adhesion with curved scissors and cauterized the raw surfaces freely with this acid. Although the surfaces remained in contact, no adhesion took place afterward, and the operation was a permanent success.[1] *John N. Mackenzie.*

* The views and conclusions given above were first published by the writer in the American Journal of the Medical Sciences for October, 1880 (see also article on Larynx, Trachea, and Bronchi, Syphilis of the, in vol. iv.).

[1] Surgical Treatment of the Diseases of Children, p. 350. London, 1868.
[2] On the Transmission from Parents to Offspring of some Forms of Disease, p. 137. London, 1851.
[3] Venereal Diseases, p. 271. London, 1827.
[4] Lectures on Diseases of Children, p. 747. [5] Op. cit., p. 351.
[6] Surgical Diseases of Children, p. 291. London, 1860.
[7] See Trans. of the American Laryngological Association, 1883, p. 185.

PHARYNX AND PALATE, ANATOMY AND PHYSIOLOGY OF THE. The *pharynx* belongs to both the respiratory and the digestive tracts, although it is usually described as a part of the latter.

Its upper portion is concerned exclusively in respiration, while the lower regions participate in both functions.

Its relations to the formation of the voice are accessory to the respiratory function, and will be described in the article on the Voice.

It is a hollow, musculo-membranous structure, suspended from the base of the skull and reaching as far downward as the interspace between the fourth and fifth cervical vertebræ.

It is attached above to the pharyngeal spine on the inferior surface of the basilar process of the occipital bone, and to two membranous bands extending thence to the apex of the petrous portion of the temporal bone, on either side. It is then attached anteriorly to the posterior border of the internal pterygoid plate of the sphenoid, to the pterygo-maxillary ligament, to the posterior extremity of the mylo-hyoid ridge on the inferior maxillary, to the base of the tongue, to the mucous membrane of the mouth, to the posterior extremities of the greater and lesser cornua of the hyoid bone, to the thyro-hyoid ligament, to the posterior border and external surface of the ala of the thyroid cartilage, and to the lateral aspect of the cricoid cartilage.

Posteriorly, it lies against the anterior surfaces of the five upper cervical vertebræ and the longus colli and recti anteriores muscles, from which it is separated by some loose connective tissue. Below, it is continuous with the œsophagus, which has its superior attachment to the posterior surface of the cricoid.

It communicates above, with the nasal passages and Eustachian tubes; below, with the mouth, larynx, and œsophagus.

The pharynx is divided, for convenience in description, into three portions: the superior, or naso-pharynx, the middle, or oro-pharynx, and the inferior, or laryngo-pharynx. The naso-pharynx is limited above by the roof or vault, and extends as far downward as the inferior border of the velum pendulum palati. It receives the orifices of the Eustachian tubes, and of the posterior nares, or *choanæ*. The former orifices, which project into the pharynx somewhat as the cervix uteri protrudes into the vagina, are just posterior to the openings of the posterior nares. Anteriorly to them is a depression, on either side, bounded in front by the crescentic margin of the orifice, which has been named by Tortual the *sinus pharyngis superior*. Posterior to them is a depression known as the fossa of Rosenmüller, or *recessus pharyngeus*.

The oral portion, or oro-pharynx, is that which extends from the level of the lower margin of the velum to the plane of the greater cornua of the hyoid bone. In front it looks toward the mouth and epiglottis, with the dependent uvula forming a very incomplete anterior wall. Two folds of mucous membrane, the pharyngo-epiglottic folds (see Larynx), help to bound it laterally.

The inferior or laryngeal portion (laryngo-pharynx), extends from the greater cornua of the hyoid bone to the inferior border of the cricoid cartilage. It looks anteriorly toward the epiglottis and ary-epiglottic folds, and is continuous, centrally, with the vestibule of the larynx; more laterally, with the pharyngo-laryngeal sinus, or *sinus pyriformis* (see Larynx).

The pharyngeal walls are composed of three layers: an internal or mucous, a middle or fibrous, and an external or muscular.

The muscles of the pharynx are fourteen in number, though two of them—one pair—are common to it and

the soft palate. They are the superior, middle, and inferior constrictors, which form the bulk of its walls and give to it its form and the greater part of its attachment; the stylo-pharyngei, and the palato-pharyngei. The muscles of the soft palate are intimately associated with its functions.

The superior constrictor (Fig. 2867) (*cephalo-pharyngeus*) is broad and flat. It takes its origin from the lower third of the posterior border of the internal pterygoid plate; from the pterygo-maxillary ligament, the base of the tongue, and the posterior extremity of the mylo-hyoid ridge. Those fibres which are connected with the base of the tongue enter its substance and pass inward; some of them penetrating as far as the fibrous septum. All the fibres pass backward and somewhat upward. The most superior are attached to the ligament which suspends it from the base of the skull, the *ligamentum suspensorium pharyngis*. The others, in part, interlace with those of the opposite side, while the remainder attach

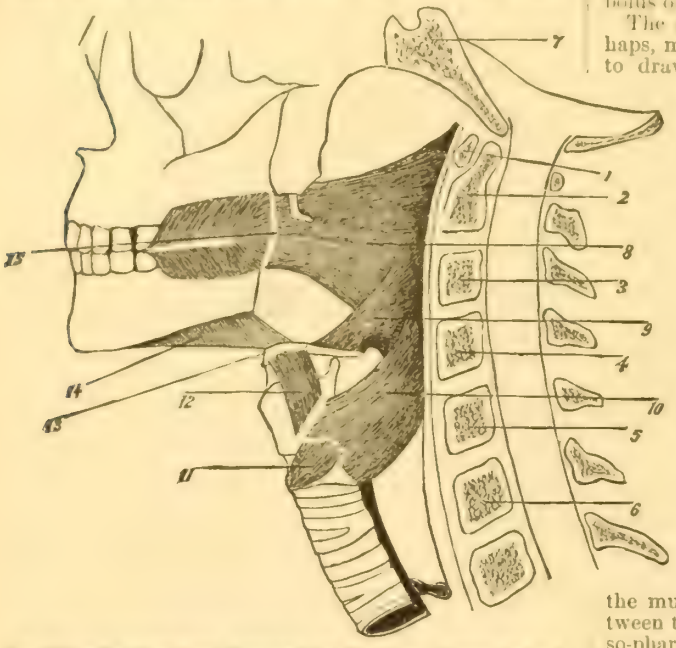

Fig. 2867.—The Constrictor Muscles of the Pharynx. (Drawn by Dr. A. H. P. Leuf.) 1, Anterior arch of atlas; 2, body of axis; 3, 4, 5, 6, bodies of third, fourth, fifth, and sixth cervical vertebræ; 7, basilar process of occipital and body of sphenoid; 8, the superior constrictor; 9, the middle constrictor; 10, the inferior constrictor; 11, crico-thyroideus; 12, thyro-hyoideus; 13, the body of the hyoid bone; 14, mylo-hyoid muscle; 15, buccinator.

themselves to the more or less distinct fibrous raphé which extends, in the median line, throughout the length of the pharynx.

The middle constrictor (hyo-pharyngeus) (Fig. 2867), arises from the greater and lesser cornua of the hyoid bone and the lower end of the stylo-hyoid ligament. From this narrow origin the fibres spread out in a fan-like shape. The more superior bundles pass upward and backward, on a plane external to the superior constrictor, ascending almost to its superior border. The middle fibres take a horizontal direction, and the lower ones pass downward, internally to those of the inferior constrictor. Part of the fibres end at the median raphé, into which they are inserted; the remainder interlace with those of the opposite side.

The inferior constrictor (*laryngo-pharyngeus*) is a somewhat quadrilateral muscle, situated at the lower portion of the pharynx on a plane posterior to the middle constrictor. Its origin is from the posterior border of the thyroid cartilage and the triangular space behind the oblique ridge into which the sterno-thyroid muscle is inserted, and from the lateral aspect of the cricoid cartilage. The superior fibres extend backward and slightly upward, interlacing in the median line. The middle and inferior bundles pass horizontally backward in a similar manner. The lowermost bundles are in close contact with those of the œsophagus.

The stylo-pharyngeus (*levator laryngis*) is long and slender. It arises from the base of the styloid process of the temporal bone. Its fibres pass downward, forward, and inward. At first they lie in contact with the outer surface of the superior constrictor, but subsequently penetrate between it and the middle constrictor, and spread out in the fibrous layer of the pharynx, the pharyngeal aponeurosis. They are, finally, inserted into the superior and posterior borders of the thyroid cartilage.

The palato-pharyngeus will be described with the muscles of the soft palate.

The action of the constrictors is to contract the lumen of the pharynx in swallowing. This action begins in the superior constrictor, and extends from above downward in a vermicular or peristaltic manner, so as to carry the bolus onward into the œsophagus.

The action of the stylo-pharyngei, which might, perhaps, more properly be called the levatores laryngis, is to draw the larynx upward toward the base of the tongue. It, at the same time, raises the lower portion of the pharynx, shortens the tube, and facilitates the entrance of the morsel into the œsophagus.

The middle, or fibrous, layer of the pharynx, known to anatomists as the pharyngeal aponeurosis, is made up of tough, closely woven, fibrous connective tissue. Above, it is attached to the pharyngeal spine, on the basilar process of the occipital bone, by means of the suspensory ligament, and to the petrous portion of the temporal bone. Between these points it forms a festoon above the concavity of which the Eustachian tube passes downward, forward, and inward to its opening into the naso-pharyngeal space. Anteriorly it is attached to the internal pterygoid plate, the pterygo-maxillary ligament, the mylo-hyoid ridge, the cornua of the hyoid bone, the thyro-hyoid ligament, the superior and posterior borders of the thyroid cartilage, and the cricoid cartilage. Below, it blends with the fibrous coat of the œsophagus. The pharyngeal aponeurosis, besides giving strength to the pharynx, affords attachment to the free ends of the muscular fibres. It is pierced, in the interval between the superior and middle constrictors, by the glosso-pharyngeal nerve, which lies just below the stylo-pharyngeus muscle, and between the middle and inferior constrictors by branches of the superior laryngeal branch of the pneumogastric. The posterior median raphé is a thickened portion of the fibrous aponeurosis. It is more marked above than below.

The mucous membrane of the pharynx is continuous with that of the nasal passages, Eustachian tubes, mouth, larynx, and œsophagus. Superiorly, it arches over, beneath the base of the skull, so as to completely close the cavity, forming the roof or vault of the pharynx.

It is closely attached to the subjacent tissues in the upper portions, but in the vicinity of the larynx its attachment is much looser, and it may, in the cadaver, be easily raised with the forceps. Above the level of the inferior border of the soft palate, that is, in the naso-pharyngeal space, it is covered by columnar, ciliated epithelium, throughout its entire extent in infancy, and in the neighborhood of the nasal and Eustachian orifices in adults.

In the oral and laryngeal regions, it is supplied with stratified pavement epithelium. The mucous membrane is liberally furnished with mucous glands, particularly in the lower regions. In the vault of the pharynx are many so-called follicular or adenoid glands, most numerous behind the orifices of the Eustachian tubes, and passing across from one tube to the other.

The glandular tissue of the vault, from its resemblance to that of the tonsils, was called by Luschka the pharyngeal tonsil. Beside these glandular structures, the con-

nective tissue of the mucosa contains many lymphoid cells.

Normally, the color of the mucous membrane of the naso-pharynx is a little paler than that in the oral and laryngeal portions.

The pharynx receives its vascular supply from the ascending pharyngeal, from the vidian and pterygo-palatine branches of the internal maxillary, and from the ascending palatine and tonsillar branches of the facial artery—all originating from the external carotid. Its veins are branches of the internal maxillary, inferior palatine, and internal jugular.

The lymphatics, which are numerous, are connected with the deep cervical glands in the neighborhood of the cornua of the hyoid bone, and in the pterygoid region.

The sensory nerves of the pharynx are the fifth, glosso-pharyngeal, and branches from the pharyngeal plexus, which is made up of communicating fibres from the pneumo-gastric, glosso-pharyngeal, superior laryngeal, and branches from the superior and middle cervical ganglia of the sympathetic. The second division of the fifth supplies the vault of the pharynx and the upper portion of the opening of the Eustachian tube, while the lower portion of the naso-pharynx has some fibres from the inferior division. Below this the sensory fibres are from the glosso-pharyngeal and the pharyngeal plexus. The fact that abnormal irritations of the region supplied by the glosso-pharyngeus give rise to vomiting has led some to call this nerve "the nerve of nausea." The pharyngeal branches of the glosso-pharyngeus are not endowed with the gustatory sense.

Fig. 2868.—Posterior View of the Pharynx. (Drawn by Dr. A. H. P. Leuf.) The median raphé is drawn too broad. 1, Base of the skull; 2, fibrous membrane of the pharynx; 3, superior constrictor; 4, middle constrictor; 5, inferior constrictor; 6, œsophagus; 7, trachea.

Motor Fibres.—The stylo-pharyngeus is supplied with motor fibres by the glosso-pharyngeal nerve. The constrictors are supplied by the glosso-pharyngeus and the pharyngeal plexus. The inferior constrictor also receives a branch from the superior laryngeal branch of the pneumogastric.

Physiologically, the pharynx is concerned both in respiration and in alimentation. During the greater part of life it remains relaxed and open, so as to admit the free access of the current of air, as it passes downward from the nasal passages to the larynx and trachea. During deglutition the respiratory function is suspended; the mouth is closed, and communication with the naso-pharynx is entirely cut off by the elevation and tension of the soft palate.

The soft palate, velum pendulum palati, is a musculo-membranous curtain, depending from the posterior extremity of the palate plates of the palate bone. It inclines somewhat backward, and has a depth of from an inch to an inch and a half. Its thickness is from a fourth to half an inch. It forms an arch, made double by the downward projection of the uvula from its highest central point. It separates the buccal from the pharyngeal cavity. The sides, or pillars, divide, as they descend, into two diverging columns called the anterior and posterior pillars of the fauces. The anterior pillar is continuous with the base of the tongue; the posterior shades off into the lateral wall of the pharynx. Between them, as they diverge, is a recess or cavity known as the *fauces*, in which the tonsil is contained. The space between the anterior pillars and the base of the tongue, which is closed during the second part of the act of deglutition, *i.e.*, after the morsel has reached the pharynx, is called the *isthmus of the fauces*.

The soft palate is covered by mucous membrane which, on its anterior or buccal surface, corresponds in structure to the buccal mucous membrane. It contains numerous conglomerate mucous glands, identical with the buccal glands which can be seen in certain inflammatory conditions, such as buccal catarrh, scarlatina, etc., as little round elevations on its surface. On the posterior surface are the follicular glands of the naso-pharynx, besides many mucous glandules. The epithelium on the anterior surface is of the stratified squamous variety. The posterior surface is covered by columnar ciliated epithelium near the orifices of the Eustachian tubes. Elsewhere it is squamous. In infancy the entire posterior surface is covered by ciliated epithelium.

The muscles of the soft palate are ten in number, five on either side. They are the levator palati, tensor palati, palato-pharyngeus, palato-glossus, and azygos uvulæ. The levator palati (*petro-salpingo-staphylinus*) (see Fig. 2869) is a rather broad muscular band, which has its origin from the inferior surface of the apex of the petrous portion of the temporal bone. Its fibres incline inward as they descend, and, spreading out, are inserted into the fibrous tissue of the velum; many of them pass over to the opposite side. This muscle forms a slight eminence under the base of the opening of the Eustachian tube, and when it contracts, during the first part of the act of deglutition, tends to close the tube. Its principal function, however, is to draw the velum upward and backward, against the posterior wall of the pharynx. The tensor palati, or circumflexus palati (*spheno-salpingo-staphylinus*), arises from the scaphoid fossa at the base of the pterygoid process. It descends perpendicularly to the outer side of the hamular process around which it curves. A bursa is interposed between the muscle and the bone. Its fibres then assume a horizontal direction and spread out in an aponeurosis, which is partly attached to the palate plate. This muscle lies in a plane anterior to the levator. The tensor palati performs two very important functions. First, it makes the velum tense and unyielding, as it is drawn upward and backward by the levator in swallowing. Second, by means of its attachment to the inferior aspect of the Eustachian tube, it draws it open and admits air to the tympanum.

The palato-pharyngeus (Fig. 2869) is a long, round muscle, arising in the substance of the soft palate as far inward as the uvula. In the velum, its fibres are separated into an anterior and a posterior fasciculus, by the levator palati. They join, below the latter muscle, to form a narrower portion which soon widens out again into two parts, an anterior and a posterior. The anterior portion joins with the stylo-pharyngeus and is inserted into the superior and posterior borders of the thyroid cartilage; while the posterior portion spreads out, some of the fibres being lost on the lateral and posterior walls of the pharynx, others passing entirely beyond the median line to interlace with those of the opposite side. This muscle, with the mucous membrane covering it, forms the posterior pillar of the fauces. When it contracts, it draws the larynx and laryngo-pharynx upward, and through the shortening and straightening of the posterior fibres, pulls the posterior pillar inward and backward, so that it forms nearly a straight line from before backward. The slight space left between the two pillars, as they are thus approximated, is closed by the uvula. In this way a complete septum is formed between the oro- and naso-

pharynx. In the absence of the uvula, the palato pharyngei may and frequently do close this space (isthmus pharyngis), so that deglutition is not impaired.

The palato glossus (*constrictor isthmi faucium*), with the fold of mucous membrane covering it, forms the anterior pillar of the fauces.

It is situated the most anteriorly of all the muscles of the palate. It arises in the median line. The fibres of the opposite muscles interlace, and continue from one arch into the other. Thence it passes downward and forward to the side of the tongue, where it is lost beneath the mucous membrane of the mouth.

The contraction of the palato glossi approximates the sides of the isthmus, draws down the uvula, and, as the base of the tongue is raised in swallowing, cuts off all communication between the mouth and pharynx.

The azygos uvulæ (Fig. 2869) is a small, slender muscular bundle which derived its name from the supposed

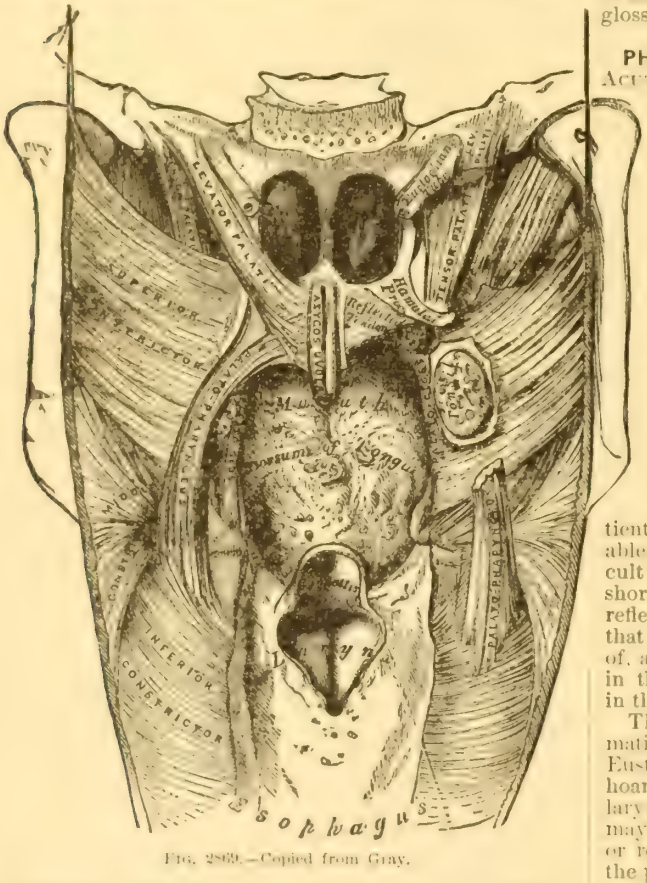

Fig. 2869.—Copied from Gray.

fact that it was single. It is now known to be bilateral, like the other skeletal muscles.

This is particularly well demonstrated in cases of bifurcated or double uvula, a not very uncommon anomaly. The azygos muscles, with their covering of mucous membrane, form the uvula, or central dependent portion of the velum palati. They arise together, partly from the connective tissue and partly from the posterior nasal spine of the palate bone. They diverge slightly as they descend, and are lost in the submucous connective tissue near the end of the uvula. When they contract they shorten and contract the uvula, and at the same time draw it upward and backward. This assists in closing the isthmus of the pharynx in deglutition, and is also an important factor in the production of speech (see Voice).

The arterial supply of the soft palate is derived from the ascending palatine and tonsillar branches of the facial; the dorsalis linguæ from the lingual; the pharyngeal branches from the ascending pharyngeal, and the descending palatine from the internal maxillary.

The veins are collected into two plexuses, anterior and posterior. The anterior are connected with the veins of the base of the tongue, while the posterior communicate with those of the nose.

The motor nerves are branches of the second and third divisions of the fifth, the facial, and Meckel's ganglion. The tensor palati is supplied by a branch from the otic ganglion, derived, originally, from the third division of the fifth. The levator palati and azygos uvulæ receive their motor innervation from the facial, by way of the great superficial petrosal and vidian nerves. The palato-glossus and palato-pharyngeus are supplied by twigs from the palatine branches of the spheno-palatine (Meckel's) ganglion. They also send some branches to the levator palati and azygos uvulæ. The mucous membrane is supplied with sensory filaments from the palatine branches of Meckel's ganglion, and the tonsillar branches of the glosso-pharyngeus. *Benjamin F. Westbrook.*

PHARYNX, CATARRHAL AFFECTIONS OF THE.

Acute Catarrhal Pharyngitis. — *Etiology.* — The causes of this affection are those of catarrhal inflammation of the upper air-tract in general, and have been considered elsewhere (see vol. iv., pp. 400–406). Among its most common exciting causes are the conditions embraced under the conception of "catching cold." It may also arise as one of the complications incident to mouth-breathing from nasal obstruction; from extension of inflammation from adjacent organs; from the suppression of a cutaneous exanthem; as a reflex phenomenon from gastro-intestinal or genito-urinary irritation; as the local expression of a constitutional dyscrasia or acute systemic infection; as the manifestation of organic disease of a distant organ, or as the direct result of local irritation. The improper use of the voice in the various forms of vocal strain is a fertile cause of pharyngeal affections.

Symptoms.—The severity of the symptoms will vary with the cause of the disorder. In mild cases there is little, if any, febrile disturbance, the patient complains of dryness of the fauces with a disagreeable sense of constriction about the throat, and of difficult or painful deglutition. There is often a peculiar, short, explosive cough which is easily recognized as a reflex act. Occasionally pain in the course of the nerves that radiate from the pharyngeal plexus is complained of, and the writer has met with intense, lancinating pain in the eyeball, brought about by localized inflammation in this region.

The disease is very frequently associated with inflammation of the naso-pharynx and may extend through the Eustachian tubes to the middle ear. Not infrequently hoarseness and the sensation of a foreign body in the larynx are added to the pharyngeal symptoms. This may be due to an irritation of the larynx, or to collateral or reflex hyperæmia of that organ, or to the presence of the pharyngeal secretion in the posterior portions of the larynx where it excites localized hyperæmia or acts as a damper on the vocal cord. The sudden loss of voice which occurs during the presence of pharyngeal inflammation is doubtless due to the latter cause.

At first, there is little or no secretion; the throat is dry and parched and is exquisitely susceptible to irritation. Later, a more or less profuse mucous or muco-purulent discharge occurs, which is expectorated by coughing or hemming.

The redness of the pharynx is generally diffuse; but is almost always more pronounced in certain portions. A common seat of the hyperæmia is along the inner and anterior aspect of the anterior faucial pillars and the palatal arcade. The veins of the posterior wall are often enlarged and prominent, and the tonsils swollen and engorged. There is slight œdema of the pharynx, which principally affects the uvula, probably owing to its dependent position, and the palatal muscles are somewhat restricted in their motions. In some cases, and especially

when the disease occurs in epidemic form, a yellowish-white pultaceous deposit takes place, which is distributed over the pharynx in small, easily detached patches. This thickened secretion is glandular in origin and it is accordingly associated with tumefaction and prominence of the pharyngeal follicles.[1] Occasionally cheesy masses are expectorated, but this is an uncommon symptom except when the acute inflammation is engrafted on chronic follicular disease.

In severe cases of acute pharyngitis the above symptoms are accentuated. Œdema occurs, which may be so great as to threaten asphyxia, or to precipitate tracheotomy, owing to direct extension of the effusion to the submucous connective tissue of the larynx. The motility of the muscles of the palate and pharynx are interfered with, deglutition is rendered difficult or impossible, and the voice acquires the familiar nasal twang which is characteristic of paralytic states of the soft palate. The condition of the muscles here is generally that of paresis from inflammatory or œdematous infiltration, and disappears with the subsidence of the inflammatory process; but occasionally a true paralysis is produced which persists after the original cause has been removed.

Pathology.—The anatomical appearances are those of simple catarrhal inflammation—engorgement of the vessels, round-cell infiltration of the mucous membrane, enlargement of the glands, and serous infiltration of the submucous tissues and muscular walls.

Diagnosis.—The affection is at once recognized by inspection. Care should be taken not to confound the whitish patches on the tonsils and pharynx, as is often done, with follicular ulceration, nor to mistake the epidemic occurrence of pharyngitis with exudation for a mild type of diphtheria. The easy removal of the deposit, the absence of abrasion after its extrusion, its obvious origin from the glandules, and its pultaceous character are sufficient to differentiate it from the organized, closely adherent membraniform exudation of true diphtheria. At the same time it should be remembered that the latter affection may originate in the follicles of the pharynx, or develop from what may seem at the first sight a simple folliculitis.

Prognosis, Complications, Sequels.—The prognosis in simple acute pharyngitis is always good. The disease generally lasts from three to seven days and ends in resolution. Repeated attacks increase the susceptibility, especially in those suffering from constitutional diseases or impoverishment of the blood from any cause. The acute pharyngitis which occurs in blood-poisoning is often a dangerous affection, death taking place from suffocation from pharyngo-laryngeal œdema; or a paralytic condition of the muscles of deglutition may be induced with the consequences which the abrogation of their functions entails.

Treatment.—The general principles governing the constitutional and local treatment of pharyngeal inflammation are indentical with those considered under the head of Acute Laryngitis (vol. iv.). Of constitutional remedies the most reliable are opium and quinine taken at the onset of the attack. Alcohol, in the form of whiskey-punch or like concoction, sometimes cuts short the duration of the disease. Local applications should be made with the spray or cotton-carrier. The act of gargling, so universally employed, is open to the objection that it brings into action parts which should be at rest. As a substitute for gargling irrigation may be resorted to or the fluid may be allowed to gravitate into the back of the throat. An excellent and simple method of overcoming the disagreeable symptoms of pharyngeal inflammation is to use in this manner, repeatedly through the day, very hot water, either alone or holding in solution soda, potash, boric acid, or allied substances. Potassium chlorate dissolved in claret wine is an agreeable and effective combination. Relief may also be had from sedative, demulcent, and astringent lozenges. Caution should be exercised in the use of cocaine. While it undoubtedly gives complete temporary relief, I am convinced that in many instances its employment prolongs the duration of the disease.

Chronic Catarrhal Pharyngitis.—*Etiology.*—The causes of chronic catarrh of the pharynx have been considered in another portion of this work (vol. iv., p. 400 et seq.). It may follow the acute or subacute form, or be due to the extension of chronic inflammation from neighboring organs, most commonly the nose and nasal pharynx. There is almost always more or less pharyngeal irritation or inflammation associated with obstructive diseases of these regions from the mouth-breathing which they necessarily involve. The habitual use of alcoholic drinks and the improper use of the voice are common causes of the disease, and in some persons the use of tobacco seems to play an important part in its production. It is occasionally the result of reflected irritation from various parts of the body or may occur as a complication of paralytic states of the muscular walls of the pharynx. It may also be the result of direct irritation from impurities in the atmosphere or from various articles of food and drink. The sudden changes from hot to cold, and *vice versa*, in the temperature of the ingesta and the injudicious stimulation of the palate by the use of condiments are sometimes important factors in chronic inflammatory conditions of the pharyngeal membrane.

Symptoms.—The symptoms of this affection are generally most marked upon arising in the morning or after prolonged and improper use of the voice and over-indulgence of the appetites. There is an accumulation of mucus in the throat which gives rise to various sensations, as of a foreign body, sense of constriction, etc. The throat is harsh and dry, the voice frequently hoarse, and the accumulated secretion, which is generally adherent, is removed by hawking or by a peculiar tickling reflex cough. These symptoms may disappear after breakfast, and in mild cases may be absent the remainder of the day. In severer cases there is a constant dryness of the throat with hawking and expectoration of viscid mucus. At night the patient may be awakened from his sleep by a sense of impending suffocation, which is only relieved upon moistening the throat and the removal of the inspissated secretion. These symptoms generally last for a long time without exciting alarm, but if neglected, the affection will ultimately end in atrophy. The membrane becomes glazed, dry, and presents a beef-tongue appearance; there is a tendency to crust-formation, and the symptoms detailed above are proportionately aggravated. As chronic pharyngitis is almost always associated with nasal or naso-pharyngeal catarrh, the individual will suffer, in addition, from the symptoms characteristic of these diseases.

Pathological Anatomy.—The anatomical changes consist in a dilated and varicose condition of the blood-vessels, especially the veins, with swelling and relaxation of the mucous and submucous tissues. The glands are enlarged and swollen, and present the appearance of minute and shining nodules scattered over the palatal arcade and uvula. In long-standing cases the contents of the follicles undergo caseous degeneration, and pellets or plugs of an offensive odor are formed, which impart a disagreeable odor to the breath (follicular pharyngitis). These are most commonly encountered in the follicular crypts of the tonsils and occasionally acquire a stony hardness (tonsillar calculus). Minute follicular ulcers often result from the discharge of the imprisoned contents of the closed follicle.

In the so-called glandular or granular pharyngitis, we may distinguish clinically and pathologically two varieties. In the one, the chief anatomical characteristic is the presence of elevations of various size and form on the free surface of the membrane (hypertrophy), and to this the term "granular" should be limited, or, perhaps, a better name would be *hypertrophic pharyngitis;* while in the other, changes in the pharyngeal follicles leading to caseous and calcareous degeneration of their contents are the distinguishing anatomical feature.

On inspection of the pharynx, the redness is found either uniformly distributed over the whole pharynx or confined to particular portions, as the palatal arcade, uvula, etc. In the pharyngitis of chronic alcoholism the mucous membrane acquires an angry red look and is

especially sensitive to local irritation. The inflammatory thickening is not always well marked, but a slightly cedematous condition, especially of the uvula, is frequently present. In many cases the whole mucous membrane presents a relaxed and flabby appearance. The pharyngeal vessels are commonly enlarged, congested, and varicose, and the follicles and follicles of the membrane are enlarged and filled with a whitish or yellowish secretion. Of common occurrence are the familiar pharyngeal granules whose nature has been variously interpreted. According to the old idea, they represented enlargements of the glands themselves. Stoerck, on the other hand, maintained that they are simply hypertrophies of the epithelium, while the researches of Saalfeld seem to demonstrate the fact that they consist of an increase in the lymphatic tissue which is found in the neighborhood of the gland-ducts. In many cases these granules seem to constitute the sole pathological element of the pharyngeal affection.

Prognosis, Complications, Sequels.—In chronic pharyngitis dependent upon a removable nasal or naso-pharyngeal affection the prognosis is good. When due to chronic alcoholism, gout, rheumatism, and allied diseases, the prospects of permanent recovery are less favorable, while in the "dry" variety (pharyngitis sicca) temporary relief is, in the vast majority of cases, all that can be looked for. The most interesting complications of chronic pharyngitis are certain motor, sensory, and vaso-motor neuroses, which will be considered in the Appendix.

Treatment.—The treatment of chronic pharyngitis should be conducted on the same general principles which have been discussed in the article on Larynx, Chronic Catarrhal Inflammation of, and which will receive further mention in the section on Chronic Nasal Catarrh in the Appendix. The great secret of success in the management of this disease lies in the recognition of the fact that, in the large majority of instances, it is a purely secondary affection, and that the chief source of pharyngeal catarrh is an inflammatory condition of the nasal passages or retro-nasal space. It is worse than useless to spray a congested or inflamed pharynx with an untreated nasal obstructive lesion or retro-nasal catarrh.

The use of gargles, sprays, and the like in the granular forms of pharyngitis is a sheer waste of time. The granules should be destroyed, and the best agent for the accomplishment of this end is the galvano-cautery. My practice is to bury the end of a small spiral electrode in the centre of the granule, and, in cases in which the growth is nourished by enlarged vessels, to make a cross-section of the latter with the cautery knife. This soon causes atrophy of the granule and marked relief to the individual. *John N. Mackenzie.*

[1] Phar.: Buffalo Med. Journal, vol. xii., p. 718.

PHARYNX, CONGENITAL MALFORMATIONS OF THE. Congenital malformations of the pharynx are of rare occurrence. Fistulous openings are sometimes found, communicating with the pharynx or the trachea, which are evidently of congenital origin. The condition has been described as an embryonic cleft-formation, and has sometimes been called fistula colli congenita.

Of congenital malformations of the neck, the pharyngeal fistula is by far the most common. To this class belong all fistulæ which open into the pharynx, or in its direction. They are divided into two varieties, the complete and the incomplete. According to Dr. George Jackson Fisher, of New York, they are apt to be hereditary, and more than one member of a family may be afflicted. Again, it has been observed that cleft-formations in other parts of the body have occasionally been associated with this variety of malformation.

Pharyngeal fistulæ are, as a rule, unilateral, and they occur more commonly on the right side than on the left. They are usually incomplete, and are found with equal frequency in males and females. Their external opening is always found upon the side of the neck, and it occurs anywhere between the sterno-clavicular articulation and the angle of the lower jaw. It may present the ordinary characteristics of a congenital fistulous opening, or, in consequence of inflammatory irritation, it may be covered with granulations and hardly large enough to admit a probe. The internal opening is found in the lateral wall of the pharynx, behind the cornu of the hyoid bone and near the basis, or in the pharyngo-palatine arch. The canal varies in length and in diameter, is usually quite tortuous, and sometimes so much so as to be almost impassable to a probe. Its diameter is always greater than that of the external opening, and it can be much increased by retained secretions, when for any reason, the opening has become stopped. The walls of the passage are thick, and they excrete a discharge which contains pavement epithelium. *D. Bryson Delavan.*

PHARYNX, TUMORS OF THE. I. Fibrous Tumors.—These growths, of fibrous structure, are generally found to originate from the vault of the pharynx, whence they may extend considerably in many directions, causing absorption or destruction of the neighboring parts, and giving rise to much annoyance and danger to the patient. The disease is rare. Dr. R. P. Lincoln, of New York, has, however, succeeded in tabulating a list of fifty-eight cases, three of which are original. Of these, not less than thirty-eight were genuine fibromata. All occurred in males under the age of twenty-five.

Observers agree that this is a disease incident to youth, and almost unknown among females. Some believe that it may be caused, in some instances, by a scrofulous condition of the patient, or by bad hygiene, although there is little to support this view. More plausible is the explanation of Morell Mackenzie, who believes that the disease is probably due to the irregular evolution, during the growing period, of a tissue which, under normal conditions, is exceptionally abundant on the under surface of the base of the skull. The age (fifteen to twenty-five) at which these growths are prone to originate is precisely the time at which the greater part of the fibrous structures of the body are at the most important stage of their development. It is then that the articular ligaments are acquiring their firmness, and it seems not unlikely that it is to an exaggerated plastic activity during this phase of growth that fibrous tumors of the pharynx owe their origin.

The early symptoms are those of obstruction to the nostril, and of the presence of an unusual object in the pharynx. Obstruction to respiration increases with the enlargement of the growth, and in case the tumor extends far downward, dyspnœa may become severe. As in cases of adenoid hypertrophy at the vault of the pharynx, deafness may result, from pressure upon the orifice of the Eustachian tube, and the sense of smell may be lost. Articulation may become thick and indistinct, and, in certain cases, there may be severe dysphagia. The secretion is generally purulent, and it may be abundant and very fetid. Epistaxis is a common symptom. It is apt to be severe, and to recur often and under slight provocation, so that it may be a prominent and dangerous feature of the case. Mackenzie calls attention to the fact that marked drowsiness and a sense of great fatigue are often observed in this condition.

The appearance of the tumor is usually smooth, its consistence hard and unyielding, and its color red or bluish-purple. Its surface is often ulcerated. As to the exact seat of its implantation, Nélaton held that the primary point of origin is, in all cases, the periosteum covering a limited area on the under surface of the base of the skull corresponding to the basilar process of the occipital bone and to the body of the sphenoid. When the tumor appears to be attached to other parts, either in the naso-pharynx or in the nose, these are merely points where secondary adhesions have been formed in the course of the expansion of the growth. In the majority of cases, at least, this view is correct, as may be demonstrated by a careful exploration of the pharyngeal cavity. Later in its development it begins to cause deformity of the adjacent bony structures. The nature of this will depend upon the direction taken by the growth. Thus, it may push the soft palate forward and downward, cause exophthalmus, invade the maxillary antrum, causing

swelling of the cheek, or produce the same result by projection through the pterygo-maxillary fissure and extension to the cheek beneath the zygoma; or, growing into the nose, it may separate the nasal bones from each other, flatten the bridge, push the eyes forward and farther apart, and thus produce the deformity known as "frog face."

Occasionally the base of the skull is perforated and the cavity of the cranium entered, in which case the brain itself may be pressed upon or eroded by the advancing growth. In some instances, seen by the writer, prolongations have been found to extend in many different directions, almost every free space in the track of the tumor having been invaded, and the cranium encroached upon as described above.

The *diagnosis* is generally not difficult if the tumor have attained considerable size. The age and sex of the patient, the general appearance of the growth, and the great infrequency of other varieties of tumor of the naso-pharynx, excepting sarcomata, will usually establish the nature of the case. Any question as to whether the growth be fibrous or sarcomatous may be settled by microscopic examination.

Pathologically, fibrous tumors of the naso-pharynx differ from similar growths in other parts only in that, as a rule, they are destitute of elastic fibres. Gross has called attention to the fact that the bloodvessels of the tumor have very brittle walls, and it is to this that he attributes their proneness to bleed, which, moreover, is favored by the vessels being embedded in a dense fibrous net-work, which does not allow of their retraction when cut. The vessels of the investing membrane are frequently of large size, while those of the substance of the tumor are usually small. Occasionally a part of the growth is of a true erectile structure.

The *prognosis* is unfavorable, unless treatment be begun at an early stage. There seems to be a tendency to absorption after the age of twenty-five, so that, if the disease can be held in check until that time, a cure may be effected. In some cases spontaneous sloughing, followed by recovery, has taken place.

The question as to what *treatment* is best calculated to meet the necessity of a well-marked case of naso-pharyngeal fibroma, it is unnecessary to say, is one of unusual importance.

Although it has been held that the affection tends toward recovery after the age of twenty-five, or, at least, that after this period of life the tumors are not apt to increase, there will be few cases in which surgical interference will not be indicated. For their removal two general varieties of procedure have been proposed: First, the old method of removal after the performance of a so-called preliminary operation, by which the region invaded by the growth was brought directly within reach of the operator; and secondly, the new method, by which extirpation is accomplished through the natural passages. When we consider the necessary remoteness of the location of such a tumor and the complicated nature of its ramifications, it will be at once evident that the extent of a preliminary operation may be unlimited, and that, under the hand of a bold operator, the safety of the patient may be seriously imperilled. Such, indeed, has often been the case, as may be proved by the records of such operations, and as has been observed in several instances and in the case of more than one operator, by the writer. With the means of observation now at our command, the region likely to be invaded by these growths can be thoroughly examined by direct inspection, so that their presence can be recognized at an early stage in their progress, and means for their relief may be applied which later might be inexpedient or of less avail.

Already a number of excellent authorities, both in this country and in Europe, have abandoned the old methods in favor of those to be later described, while increasing experience and the accumulation of a considerable amount of evidence from the statistics of cases actually treated, tend more and more to confirm the value and importance of the new methods.

Of the preliminary operations for gaining access to the naso-pharyngeal cavity, three varieties have been recognized—namely, the nasal, the maxillary, and the palatine. In the first the growth was reached through the anterior nares, the external covering of the nose having been removed. For this several operations have been proposed. Among them the one to be preferred is that of Rouge. This is performed by raising the upper lip and incising the mucous membrane in the gingivo-labial groove from the first molar tooth on the left side to a corresponding point on the right, the centre of this incision being at the frenum of the lip, which is divided at the root. The tissues are cut through in their whole thickness, until the anterior nasal spine is reached, when the knife is carried over this prominence, detaching the cartilaginous part of the septum at its base. This is often sufficient to enable the operator to raise the lower part of the nose and thus expose the nasal cavities. Should it not suffice, however, the alar cartilages should be separated from their attachment to the upper jaw with scissors, and the nose, being thus completely detached, should be thrown upward upon the forehead, when the whole extent of the opening of the anterior nares will be exposed. If the uncut portion of the septum prevent the turning back of the nose it should be divided with scissors. When the operation is completed the wound should be carefully cleansed and the lip replaced. Union will take place without the aid of sutures. The operations of Chassaignac, Langenbeck, and Ollier, with their modifications, are more complicated, and are likely to produce greater disfigurement.

The maxillary operations consist in the excision and temporary resection of the maxillary bone, which may be removed entirely, or in part, or it may be temporarily displaced.

The palatine operations for the subsequent removal of naso-pharyngeal fibromata consist in the division of the soft palate in the median line, or in the division of the pillars of the fauces at both sides, with the view of making the velum palati more movable. The best procedure of this kind was proposed by Maisonneuve, who made a longitudinal incision through the soft palate, commencing close to the posterior edge of the palate bone, and carrying the knife to within one centimetre of the edge of the velum. Through the incision thus formed the finger is passed to explore the size, shape, and attachments of the growth, which is then drawn through the wound, surrounded at a point as near as possible to the base by a wire noose and gradually cut through. Trephining the hard palate, with removal of a considerable area of bone, has also been practised.

In connection with some one of the preliminary operations alluded to above, the final removal of a growth has been accomplished by ligation, the écraseur, evulsion, excision, crushing, gouging, the actual cautery, and the application of escharotics.

Of late years the method of dealing with these growths has undergone an important change, and through the aid of the electric cautery and electrolysis, applied through the natural passages, results have been obtained which promise to revolutionize the views formerly held as to their treatment. In the employment of the *electric cautery* the best method is, if possible, to surround the base of the growth with the galvanic écraseur passed either through the nose or through the mouth. The stump should afterward be thoroughly destroyed by the electric cautery, applied at intervals of a week. For this purpose several good cautery electrodes are now to be had, while the recent improvements in cautery batteries have made it possible to secure a reliable and simple instrument at a moderate cost.

Electrolysis can be applied by any battery generating a continuous current of moderate strength. One or more curved needles connected with the negative pole should be introduced directly into the tumor, while the positive pole, through the medium of a sponge electrode, should be applied to the sternum. The operation should be continued for ten or fifteen minutes at a sitting, and repeated every day or every other day. Excellent results have been reported from this method.

Although operations through the natural passages have

been done to some extent abroad it is to Dr. Rufus P. Lincoln, of New York, that credit is chiefly due for having clearly demonstrated, by means of carefully collected statistics and by his own remarkable series of cases, the extraordinary advantages of the less heroic measures over those formerly employed. In a series of twenty-one cases of fibromata collected by Dr. Lincoln, in which a preliminary operation was performed, three patients died upon the table, and a fourth succumbed within a few hours. A fifth patient nearly died from hæmorrhage while the operation was in progress. On the other hand, of eight cases, the records of which were collected by Dr. Lincoln, in which the operation was performed through the natural passages, recovery followed in every instance. In the opinion of the writer, the rate of mortality from the old methods of operation would be greatly increased if the unsuccessful cases were invariably placed upon record.

II. Fibro-mucous Polypi.—These are growths composed of a mixture of the structural elements of the tissue from which they originate. Those which grow in the neighborhood of the posterior nares, in a situation where the membrane is partly of the nature of the pituitary membrane, and partly of that of the lining of the vault of the pharynx, which latter is rich in fibrous elements, partake of the nature of both. They vary from a tumor of small size to one as large as a hen's egg, and are generally smooth, dark red, and ovoid in form.

They are probably more common than true fibromata. The symptoms to which they give rise are principally those of nasal obstruction, although they sometimes cause catarrh and deafness. They are otherwise harmless to the surrounding structures, and are not prone to bleed. They show little tendency to recur when removed, and may be extirpated by evulsion and forceps, or, better still, by the Jarvis écraseur. The galvano-cautery loop may be employed, although it does not seem to offer any advantage over the cold wire.

III. Enchondroma.—Enchondroma of the naso-pharynx is of such rare occurrence that it is practically unknown. Cases are on record, however, in which a fibrous tumor is said to have degenerated into an enchondroma.

IV. Malignant Tumors.—Malignant tumors of the naso-pharynx are probably not so rare as the records would indicate, since it is possible that certain cases reported as fibromata may have been of the former nature. It is said that a fibroma has, in certain rare instances, degenerated into a sarcoma. The symptoms are similar to those of fibromata, but to these are added in certain cases severe pain, of a lancinating character, which is apt to be referred to the ear and to be worse at night, severe dysphagia, and general cachexia. Sarcomatous tumors may be pedunculated, while sometimes they are more or less distinctly lobulated. They present no special features to the eye or to the touch by which their true nature can be detected. The diagnosis can be established by the aid of the microscope. The prognosis is absolutely bad. The progress of development is rapid, recurrence after removal being almost certain, and in many cases there is a disposition toward the formation of secondary deposits in other organs. The best plan of treatment consists in early recognition of the growth, and its removal by the galvano-cautery. By this means it is possible that the prognosis may be modified, and that a measure of success greater than that attained by the older methods of extirpation may be reached.

Great care should be taken after removal to watch for any signs of recurrence, and, in the event of such a misfortune, to attack the disease at once.

V. Dermoid Tumors.—The occurrence of these strange abnormalities must be decidedly rare, since in the best standard works they are not even mentioned. In recent periodical medical literature, however, the writer has come upon the records of about a dozen cases, and he has seen one well-marked instance, which was discovered and operated upon by Dr. Clinton Wagner, of New York. The growths are undoubtedly congenital, and they must be caused by the misplacement, during an early period of fœtal life, of embryonic elements intended for the formation of structures at the opposite and external extremity of the Eustachian canal. In the case seen by the writer, the patient, a healthy Irish girl of twenty, was unaware of the existence of the tumor until a fortnight before the time of the operation. Inspection of the pharynx revealed a pale, rounded excrescence, about a fourth of an inch thick in its antero-posterior dimension, and extending downward from behind the velum palati to a point about half an inch below its free border and from the left lateral wall of the pharynx to the median line. It was attached to the posterior aspect of the hard palate immediately below the orifice of the left nasal fossa. Its presence seemed to have caused no particular irritation. Microscopic examination showed it to consist of an integument containing all of the anatomical elements of true skin and abundantly furnished with hair-follicles containing hairs, many of which were visible to the naked eye; under this was a delicate superficial fascia; next, a layer of fat, and under this a double plate of cartilage, covered by a true perichondrium; the whole structure was identical with that of the helix of the ear.

D. Bryson Delavan.

PHENOL, POISONING BY. This substance, now a very familiar antiseptic, is known more generally as carbolic or phenic acid, also as coal-tar creasote. True creasote, the characteristic ingredient of wood-tar, especially that from beech-wood, is not identical with phenol.

Phenol, as the common name indicates, has some acid properties, but is, more strictly speaking, an alcohol. Its formula is C_6H_5HO. When pure it is a colorless, crystalline, deliquescent mass, soluble in water, alcohol, and glycerine, with a well-marked odor, and burning taste. The *crude carbolic acid* of commerce is variable in composition, and often consists of little else than neutral tar-oils, which are destitute of any antiseptic qualities.

Applied to the skin, phenol produces a white superficial eschar; on the mucous surface the effect is more severe. Allen ("Com'l Org. Anal.") states that its effects are much more severe and dangerous when applied extensively to the skin of the lower half of the body than when applied to the upper half. A number of cases are recorded in which death has resulted from external application, even to a limited surface. The recently introduced use of phenol in antiseptic surgery has been responsible for several fatal cases.

When phenol is swallowed in moderate concentration an intense burning sensation is immediately experienced in the throat, œsophagus, and stomach, the mucous membrane becoming white and hardened. Vomiting of a frothy mucus occurs. The skin becomes cold, the lips and ears livid, pupils contracted and insensitive, and breathing difficult; the pulse may be 120 and irregular. The urine becomes dark-colored, and may be suppressed. These symptoms are soon followed by insensibility, with stertorous breathing. The appearances after death are largely those of local action of the poison, but the train of symptoms shows that, like nearly all other poisons, there is a distinct action on the nervous system to which the fatal result is largely due.

The fatal quantity is somewhat difficult to fix, owing to the great variation in strength of the commercial solutions, in which form the acid is generally encountered in cases of poisoning. One case noted by Taylor, a woman, died in about half an hour after swallowing a wineglassful of, probably, a weak aqueous solution of phenol. The minimum fatal dose is given by some authorities as one drachm, but recovery from such an amount is possible. Half an ounce is almost invariably fatal. Fatal results have several times occurred rather rapidly, that is, in less than an hour.

The treatment is to use Epsom salt (magnesium sulphate), or sodium sulphate, freely, and to wash out the stomach by means of the pump with solutions of these substances. Emesis may, if necessary, be secured by the use of apomorphine hypodermatically. The stomach should, if possible, be washed out with tepid water until the odor of the acid has disappeared. The internal ad-

ministration of the official syrup of lime is also antidotal. Atropine is regarded as a physiological antagonist, and may be used hypodermatically to combat the general symptoms. When the acid has been accidentally applied externally in excess, thorough washing with water will usually suffice, with or without the addition of sodium carbonate.

Henry Leffmann.

PHILADELPHIA. The accompanying chart, representing the climate of the city of Philadelphia, Pa., and obtained from the Chief Signal Office at Washington, is here introduced for convenience of reference. A detailed explanation of this and of other similar charts is given in the general article on Climate (vol. ii., pages 189 to 191), where also the reader will find suggestions as to the best method of using these charts. *H. R.*

Climate of Philadelphia, Pa.—Latitude 39° 57′, *Longitude* 75° 9′.—*Period of Observations, January* 1, 1871, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 42 *feet.*

	A			AA	B		C	D	DD	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Mean daily range of temperature.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	29.0	35.0	30.8	31.6	40.9	25.8	38.9	24.8	14.1	67.0	44.0	19.0	−5.0	22	30
February...	30.1	38.2	32.8	33.7	39.6	25.6	43.5	29.0	14.5	75.0	52.0	20.0	−1.0	23	16
March	35.7	44.4	38.5	39.5	48.6	31.7	48.9	34.1	14.8	75.0	59.0	35.0	5.0	22	24
April.....	45.7	56.0	47.8	49.8	57.1	42.6	59.2	42.8	16.4	87.0	64.0	41.0	17.5	18	24
May.....	57.8	69.3	59.4	62.1	68.3	57.3	71.7	53.6	18.1	96.0	82.0	48.0	36.0	25	26
June.....	67.9	77.7	68.5	71.3	73.9	67.1	79.7	62.6	17.1	97.0	89.5	60.0	49.0	22	21
July.....	72.8	82.5	73.7	76.3	78.4	74.8	85.0	68.4	16.6	100.0	90.0	68.0	56.0	22	18
August.....	70.6	79.7	71.4	73.9	76.9	71.3	81.7	66.5	15.2	99.0	85.0	65.0	53.0	23	24
September..	62.7	72.4	64.5	66.5	74.8	62.6	76.1	60.5	15.6	101.5	81.0	54.0	43.0	26	16
October	52.2	62.4	54.1	56.2	61.4	50.4	66.9	50.9	16.0	87.0	74.0	45.0	31.0	22	20
November..	39.9	47.6	42.1	43.2	48.0	38.0	52.4	38.5	13.9	77.0	56.0	28.0	8.0	21	19
December..	31.7	37.6	33.8	34.3	41.7	25.1	43.4	30.2	13.2	70.0	48.0	22.0	−5.0	23	23
Spring	.....	.....	.....	50.4	56.9	47.1	....	....	....	.....	.....	.....	.....	.....	.....
Summer....	.....	.....	.....	73.8	75.5	72.4	....	....	....	.....	.....	.....	.....	.....	.....
Autumn....	.....	.....	.....	55.3	61.0	55.6	....	....	....	.....	.....	.....	.....	.....	.....
Winter	.....	.....	.....	33.2	39.5	28.6	....	....	....	.....	.....	.....	.....	.....	.....
Year	.....	.....	.....	53.2	54.6	50.1	....	....	....	.....	.....	.....	.....	.....	.....

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	Miles.
January....	72.0	74.4	11.5	6.5	18.0	3.25	N.W.	10.4
February...	76.0	68.7	10.2	7.7	17.9	3.01	N.W.	10.9
March.....	70.0	66.0	11.5	7.5	19.0	3.27	N.W.	12.1
April.....	69.5	62.9	11.2	7.8	19.0	3.16	N.W.	11.1
May.....	60.0	63.4	10.5	11.3	21.8	2.78	S.W.	9.6
June.....	48.0	68.2	14.0	8.2	22.2	3.63	S.W.	9.0
July.....	44.0	67.2	13.4	9.7	23.1	4.41	S.W.	8.4
August.....	46.0	71.8	9.8	10.8	20.6	5.05	S.W.	7.6
September..	58.5	71.4	10.8	10.7	21.5	3.73	S.W.	8.3
October	56.0	69.5	11.7	11.2	22.9	2.97	S.W.	9.3
November..	69.0	68.6	11.0	9.0	20.0	3.37	N.W.	9.6
December..	75.0	72.3	12.8	6.1	18.9	2.54	N.W.	10.0
Spring	91.0	64.1	33.2	26.6	59.8	9.21	N.W.	10.9
Summer....	51.0	69.1	37.2	28.7	65.9	13.09	S.W.	8.3
Autumn....	93.5	69.8	33.5	30.9	64.4	9.97	S.W.	9.1
Winter	80.0	72.0	34.5	20.3	54.8	8.80	N.W.	10.4
Year	106.5	68.7	138.4	106.5	244.9	41.07	N.W.	9.7

PHIMOSIS. Phimosis signifies such a narrowing of the preputial orifice that retraction of the prepuce behind the corona glandis is either impossible or difficult. This condition may be either congenital or acquired; when acquired it may be either temporary or permanent, and whether congenital or acquired it varies in degree from cases so slight that the larger portion of the glans can be uncovered, to cases so marked as to offer a serious impediment to micturition. During early childhood the prepuce is naturally excessive as compared with the adult, and the preputial opening is often small. Many boys reach puberty without ever uncovering the glans. In ordinary cases, when the prepuce offers no impediment to urination, no anxiety need be felt, as the organ usually assumes a normal condition with adult age. In certain cases the prepuce seems truly hypertrophied, having an abnormal length and thickness, and extending beyond the glans so as to constitute a supplementary canal. When the preputial opening is smaller than the true meatus the urine dilates the prepuce during micturition; smegma is retained, its secretion is increased, and inflammation is set up, which results in adhesions of greater or less extent.

Acquired phimosis is the result of some local disease of venereal or other origin, which diminishes the size of the prepuce or enlarges the glans. As a temporary condition it is a frequent result of œdema and swelling in gonorrhœa, and of the induration of the true chancre. The swelling may also be sufficient, in other affections, to cause phimosis, viz., in balanitis, herpetic ulceration, papillomata, or epithelioma. The impossibility of uncovering the glans to discover and treat the morbid condition has sometimes the effect of aggravating the local malady, but complete cleanliness and the avoidance of attempts to retract the foreskin, which only serve to increase the irritation and inflame the tissues, usually result in a favorable termination. Phimosis in these cases is often simply œdematous; but it may become phlegmonous when, once induced by any of the causes already mentioned, it is aggravated by excess of any sort. The indurated chancre can generally be diagnosed by the touch, and it is not necessary to see the sore in order to treat it.

Phimosis is a not infrequent symptom of diabetes, and is then accompanied by an intense pruritus, with superficial excoriations. Most of the older authorities counsel against circumcision in diabetic phimosis, but M. Françon[1] reports two successful operations, and thinks the operation less likely to be followed by disastrous consequences than has been supposed.

A permanent acquired phimosis follows any acute form when a loss of substance, with subsequent contraction and cicatrization, makes the disproportion lasting.

The consequences of phimosis may be very serious. When the orifice is so small as to cause an impediment to the flow of urine, exactly the same train of symptoms

may follow as from a stricture in the urethra itself. The continual straining of a child with a tight phimosis to empty his bladder may cause a hernia. Dr. Hans Schmid[1] of Berlin, has studied the relationship of hernia and phimosis in children, and gives figures from the Policlinic which strongly support the idea of a connection between the two pathological conditions. Hydrocele would appear, by the same figures, to be caused in the same way. Prolapse of the bowel, a common result of stone in the bladder, may also result from straining when a phimosis causes a hindrance to the escape of urine. Incontinence of urine is an occasional result of phimosis. The sensory nerve-filaments from the cutaneous and mucous surface of the end of the penis interlace with the muscular nerve-supply of the walls of the bladder, and irritation of the former may be followed by contraction of the walls of the bladder. The reference of pain to the wrong spot, because of this interlacing of nerve fibres, is well understood, particularly the pain at the end of the penis, as a symptom of stone. The contraction of the bladder, when the end of the penis is irritated, is but the converse of this well known symptom.

The accumulation of sebaceous matter beneath a phimosis, acting as a peripheral irritant through the internal pudic nerves, is considered a cause of central nervous disease which may be more or less grave according to the constitution of the child and the amount of local irritation. Jullien[2] thinks it not rare "to see patients with a tight phimosis arrive at a neuropathic state which has great resemblance to hysteria, and leads frequently to hypochondria, migraine, palpitation of the heart, gastralgia, passing congestions of various organs, facial neuralgia, spasms and pain at the neck of the bladder—simulating sometimes the presence of a calculus—lassitude, muscular feebleness," etc. In a very interesting case, where the symptoms had been particularly noticed, Verneuil verified the existence, upon the excised prepuce, of a considerable hypertrophy of the terminal nervous plexus.

Dr. Sayre,[4] of New York, has called attention to certain cases of paralysis of the lower extremities, and other pathological conditions in boys with phimosis, in which the organ is in a state of almost constant priapism.

While these remote results of phimosis must be admitted, it is proper to add a word of caution against considering all the ills of boyhood as due to a slight narrowing of the prepuce. Children have been circumcised by very judicious practitioners with the hope of relief in well-marked and unmistakable hip-disease, and parents have been led to hope that feeble children owed their lack of vitality to phimosis, to the neglect of very obvious errors in diet and hygiene.

Calculi are sometimes formed beneath a phimosis. Such concretions consist of phosphate of lime and ammonio-magnesian phosphate, with organic matter.

Treatment.—The indications are, of course, to enlarge the orifice sufficiently to allow easy retraction, and consequent cleanliness. The enlargement of the orifice may be accomplished in various ways. When relief is required in a person liable to severe hæmorrhage from trivial wounds, in the aged, or in persons who refuse an operation, persistent treatment with some instrument that acts like a glove-stretcher may be instituted. The instrument used to hold open the trachea during the insertion of the tube in tracheotomy is very convenient, or an instrument may be improvised from a spring clothes-pin.

A slit along the dorsum, or one on each side of the frænum, is sometimes advised. The result in such cases is not alway satisfactory, very ugly-looking flaps being left. There are, however, many cases in which there is no redundancy of tissue, and the constriction is confined to a narrow ring at the junction of the skin and mucous membrane, in which an incision of half or three-quarters of an inch on the dorsum will relieve the phimosis quite as effectually as a complete circumcision, and without interference with the patient's ordinary avocations. In doing such an operation it is well to locate the exact point of constriction by retracting the prepuce until the narrowest portion is stretched over the glans, when one blade of a pair of scissors may be slipped beneath the prepuce and the necessary cut made. Occasionally a mother hesitates to submit her boy to a complete circumcision, and the surgeon may give the child very great relief by enlarging the preputial opening in this manner. Care should be taken to retract the prepuce occasionally for a few days. The excision of a V-shaped piece from the dorsum leaves a rather better-looking prepuce. Skin and mucous membrane may be united by sutures, or left to unite as they will.

In the majority of cases, however, circumcision is the proper remedy. The operation is made the subject of a separate article.

It is seldom necessary to operate on an œdematous or inflammatory phimosis. The organ should be kept elevated, all constriction carefully avoided, and perfect cleanliness obtained by washing out the cavity with some disinfecting fluid.

Phimosis due to an indurated chancre may be relieved by internal medication. When the result of cicatrization, phimosis can, of course, be cured by operation only.

Abner Post.

[1] De l'operation du phimosis chez les diabetiques, par M. François. Lyon Medical, October 24, 1886. [2] Centralblatt f. Chirurgie, July 11, 1885.
[3] L. Jullien: Maladies Vénériennes, 2d ed., p. 175.
[4] Sayre: Lectures on Orthopædic Surgery, Lecture iii.

PHOSPHORIC ACID. By *phosphoric acid* is signified, in medicine, a solution of common or orthophosphoric acid (H_3PO_4) in water. Two grades of strength of such solution are officinal in the U. S. Pharmacopœia, as follows:

Acidum Phosphoricum, Phosphoric acid. This preparation is made by an elaborate process, of which the principle is the oxidation of phosphorus by the action of hot nitric acid. The product, duly purified, is evaporated down until one hundred parts represent fifty parts of orthophosphoric acid. It then appears as "a colorless liquid, without odor, of a strongly acid taste and reaction. Its specific gravity is 1.347" (U. S. Ph.). It should be preserved in glass-stoppered bottles.

Phosporic acid is intensely acid and irritant, but does not immediately corrode living tissues and coagulate albumin, as do the majority of the strong mineral acids. In any considerable quantity, however, this grade of the acid would prove a sharp, and very likely fatal, irritant poison if swallowed without dilution. This strength of acid is rarely prescribed in medicine, being officinal simply as a convenient solution to be kept in stock by the druggist for the making of the following, the commonly prescribed preparation:

Acidum Phosphoricum Dilutum, Diluted Phosphoric Acid. This grade of the acid is compounded by mixing twenty parts of the foregoing strong acid with eighty parts of distilled water. The solution thus contains ten per cent. of orthophosphoric acid, and has the specific gravity 1.057. This acid resembles in general properties the other diluted mineral acids (see Sulphuric Acid), but is distinguished by having a pleasanter flavor (its acidity resembling that of the fruit acids) and by being, as a rule, better borne by the stomach than its congeners. It may, therefore, be used for the common purposes of the mineral acids, to allay thirst, improve digestion, repress tendencies to sour fermentation of the contents of stomach or bowels, and to check morbid sweating. By many it is further claimed that phosphoric acid, ingested, tends to revive an exhausted nervous system, to excite the sexual function, and generally to enhance nervous activity and power. By such claimants the acid is regarded as the therapeutic equivalent of uncombined phosphorus; but certainly it fails in that most pronounced therapeusis of free phosphorus, the frequent cure of neuralgia. A special claim for phosphoric acid, of capability to lessen the excretion of sugar in diabetes, is now probably pretty generally abandoned. Diluted phosphoric acid may be given in doses of from twenty drops to a teaspoonful or more, three times a day, the dose to be largely diluted with water, or with syrup and water. The precaution ob-

taining with the giving of other mineral acids, of taking the draught through a tube and rinsing the mouth after the swallowing, need not here be insisted upon in the case of this acid. *Edward Curtis.*

PHOSPHORIDROSIS. A disorder of secretion in the sweat-glands of the skin, characterized by the appearance of phosphorescent perspiration upon the surface. Examples of the disease are very rarely met with. Panceri records the case of a physician who exhibited this phenomenon after eating phosphorescent fish. Koster reports a case in which the body linen was rendered luminous by the perspiration after any violent exercise. The evolution of light from the living subject is said to have been observed in the last stage of phthisis and in miliaria.

Arthur Van Harlingen.

PHOSPHORUS. Phosphorus is available for medicinal purposes in the form of the element itself, or as it occurs in the special compound *zinc phosphide*, a compound that readily yields free phosphorus upon swallowing, under the conditions present in the stomach. Phosphorus is officinal in the U. S. Pharmacopœia under the title, *Phosphorus*, Phosphorus. It is described as "a translucent, nearly colorless solid, of a waxy lustre, having, at the ordinary temperature, about the consistence of beeswax. It has a distinctive and disagreeable odor and taste, melts at 44° C. (111.2° F.), and has the sp. gr. 1.83 at 10° C. (50° F.). It is insoluble in water, soluble in 350 parts of absolute alcohol at 15° C. (59° F.), in 240 parts of boiling absolute alcohol, in 80 parts of absolute ether, in about 50 parts of any fatty oil, and very abundantly soluble in disulphide of carbon, the latter yielding a solution which must be handled with the greatest care to prevent danger from fire. When exposed to the air, it emits white fumes, which are luminous in the dark, and have an odor somewhat resembling that of garlic. On longer exposure to air, it takes fire spontaneously" (U. S. Ph.). Because of its spontaneous inflammability phosphorus "should be carefully kept under water, in a secure and moderately cool place, protected from light."

In its physiological relations, as in its chemical, phosphorus is unique. It is locally exceedingly irritant—even practically corrosive, although, strangely enough, in some experiments bits of solid phosphorus have lain imbedded in the connective tissue of animals for weeks without exciting any local reaction. Ordinarily, however, upon skin or mucous membrane phosphorus in substance excites inflammation, possibly followed by ulceration and gangrene of the area exposed to contact. Even the fumes of phosphorus may inflame exposed mucous membranes, such as the conjunctiva and the mucous membrane of the mouth and respiratory tract, and inflame even to consecutive necrosis any accessible periosteum. Thus used to arise in match factories, in the days before the use of allotropic phosphorus, cases of necrosis of the jaw, the periosteum being generally reached by the poisonous fumes through the avenue of some defective tooth. Taken internally, even therapeutic doses are very apt to irritate the stomach, as shown by loss of appetite, nausea, uneasiness, and even pain and tenderness at the epigastrium, or, in fuller grade, by the additional symptoms of vomiting and diarrhœa. Flatulence and eructations of phosphoretted gases are further disagreeable local effects of the medicine upon the digestive apparatus. Phosphorus when swallowed is readily absorbed, but exactly in what chemical status has not been definitely proven. That it reaches the blood, in part at least, as uncombined phosphorus dissolved by the alkalies of the intestinal juices or by fats, is, theoretically, certainly not impossible, and is the obvious suggestion of many chemical considerations. On the other hand, that some portions undergo various grades of oxidation is again perfectly possible and likely.

The constitutional effects that follow the internal taking of phosphorus are symptomatic of modifications of nutrition. In therapeutic dosage in health there is ordinarily little obvious derangement beyond what may be a reflex of the gastric irritation set up by the drug; and, anatomically, the most striking result of the medication is a tendency, proven by dissection of animals,[1] toward increased activity of development of bone. Cartilaginous epiphyses ossify with undue speed and completeness, spongy bone-tissues increase in thickness, and compact bone in hardness. And a similar special tendency toward nutritive activity in *nervous* tissues, under the administration of phosphorus, is commonly, and probably rightly, inferred from the two facts, first, that in nerve-tissue, as in that of bone, compounds of phosphorus are prominent normal constituents, and, secondly, that many morbid derangements of nerve-function which are fairly referrible to malnutrition or to exhaustion of nerve-tissue, tend to abate under a régime of phosphorus-medication. A special aphrodisiac action has been claimed for phosphorus, but cases where any effect of this nature has been observed have probably been cases of previous debility or exhaustion of the sexual function, where the renewed sexual desire is simply the natural consequence of restoration of power through improved nerve-nutrition. In originally vigorous subjects several series of observations have shown that phosphorus does not produce any direct aphrodisiac effect.[2]

In overdoses, single or continued, phosphorus profoundly deranges nutrition, inducing fatty degeneration of glandular and other tissues, and hæmorrhages. Death may result, or an impairment of health that is slowly and with difficulty recovered from. For a detailed discussion of this singular poisonous operation of phosphorus see article, Phosphorus, Poisoning by.

The therapeutic application of phosphorus is the internal administration of the drug for the bettering of deranged nerve-status. By far the most striking results are obtained in neuralgia, for which affection phosphorus is now pretty generally accorded the right to hold place among the standard remedies. Naturally enough, the more recent the case, the greater the chance of relief and of cure, and unless relief come within forty-eight hours, the medicine will probably fail altogether (Ashburton Thompson). In other nerve-derangements it may be said, broadly, that in such as belong to the category of the naturally curable ones, recovery may perhaps be hastened by the use of phosphorus; but that in the incurable or difficultly curable nervous diseases the agent generally does little or no good. Thus the high hopes at one time formed of the avail of phosphorus in such maladies as epilepsy and locomotor ataxia have utterly failed of realization; but in such conditions as so-called nervous prostration, or incipient dementia, the drug is often of distinct benefit.

In the important matter of the *dose* of phosphorus, there is much difference in the practice of different physicians. Some confine their dosage to 0.0006 Gm. ($\frac{1}{100}$ grain), thrice daily, while others begin at once with 0.003 Gm. ($\frac{1}{20}$ grain), given with the same frequency, and aim to increase to double the amount, under guidance of the effects wrought—curative to the disease on the one hand, or irritative to the stomach on the other. Certainly, the larger of the doses cited are well borne in a very considerable number of cases, and certainly, also, the same may succeed, and speedily too, in curing a neuralgia, where the minute dose of the timid prescriber utterly fails of all impression upon the disease.

The *mode of administration* is an all-important matter in the case of phosphorus, since by faulty prescribing the dose may be unduly irritant or nauseous on the one hand, or inert on the other. In general, phosphorus must not be given in substance, no matter how extreme the subdivision, because of irritation; and in prescription in solution a solvent must be sought that will hold the phosphorus secure against oxidation, and at the same time not furnish too disgusting a potion. The most generally serviceable solvent, where the preparation is to retain the fluid condition, is a fixed oil, freed from contaminating oxygen and water by a preliminary superheating. Squibb has strongly advocated cod-liver oil,[3] fearing vegetable oils because of an alleged tendency of phosphorus in solution in the same to "develop poison-

ous properties," presumed to be "due to the formation of hypophosphorous acid." Sweet almond oil is, however, the most generally selected of fatty solvents, and has been adopted by the authorities of the sixth revision of the U. S. Pharmacopœia as the basis of the officinal oily preparation. Chloroform and ether are inconveniently volatile for the making of a permanent fluid preparation, and carbon disulphide is too disgusting and noxious. Absolute alcohol can be made the basis of an efficient fluid mixture, as in the so-called Thompson's solution, described below. For pills of phosphorus the plan should be followed of actually dissolving the phosphorus in some fluid, which either itself hardens, by cooling, to a solid, or which, incorporated with some indifferent powder, will form a pill-mass. In either case, the indispensable feature is secured that phosphorus is in true solution still, although the pill, as such, is of course a solid. An obvious practice for the making of such pills is to dissolve phosphorus in melted resins, which on cooling reacquire the solid condition with, now, the phosphorus held in solution. But while these resinous pills are easy to make and to take, there is strong reason to fear that the contained phosphorus may be easily allowed and even helped to oxidize. The pharmacopœial procedure given below is probably as free from objection as any.

In whatever form or dose phosphorus be given, a cardinal rule, insisted upon by almost all who have had much experience with the medicine, is that the administration should never be upon an empty stomach, nor, on the other hand, *immediately* after eating.

The phosphorus preparations of the United States Pharmacopœia are two, as follows:

Oleum Phosphoratum, Phosphorated Oil. Phosphorus is dissolved by gentle heat in sweet almond oil which has been previously heated for fifteen minutes to a temperature of 250° C. (482° F.), and then cooled and filtered. After the phosphorus is fully dissolved and the solution cooled, a small charge of stronger ether is added thereto. The finished product contains one per cent. of phosphorus and nine of ether. By measure, one minim represents about $\frac{1}{75}$ grain of phosphorus (United States Dispensatory). Phosphorated oil should be clear and with a decided taste and smell of phosphorus, and the few drops which will constitute a dose (see remarks on dosage, above) may be given in capsule or in emulsion, flavored by a trace of oil of peppermint, or of gaultheria, or of bitter almond. The officinal *almond mixture* forms a convenient vehicle for an emulsion, flavored as just described. Phosphorated oil must be kept in small, glass-stopped vials in a cool place, and the phosphorus keeps best when the vials are completely full.

Pilulæ Phosphori, Pills of Phosphorus. Phosphorus is dissolved in chloroform by gentle heat and the solution added to a mixture of acacia and althæa in a mortar. A little glycerin and a little water are next poured on, and the whole rapidly beaten to a pill-mass, which is immediately cut up into the proper number of pills. Each pill is then coated with a solution of balsam of tolu in stronger ether, and when the coating is dry the pills are put up in well-stopped bottles. These pills contain, each, 0.0006 Gm. ($\frac{1}{100}$ grain) of phosphorus, and from one to five pills will constitute a dose (see remarks on dosage, above).

Unofficinal, but well-known and much used, is an alcoholic solution of phosphorus devised by Ashburton Thompson, of England, and commonly called *Thompson's Solution of Phosphorus*. It is prepared as follows: One grain (0.065 Gm.) of phosphorus is dissolved in five fluidrachms (16.00 Gm.)* of *absolute* alcohol by the aid of heat, and the solution added to a *warmed* mixture of one and a half fluidounce (56.25 Gm.) of glycerin and two fluidrachms (6.68 Gm.) of alcohol. When the resulting mixture has cooled, forty minims (2.12 Gm.) of spirit of peppermint is added. The preparation should be a bright, clear, colorless solution, wherein the odor and taste of phosphorus are almost completely masked by the pungency of the alcohol and peppermint. It is essential that the alcohol used to dissolve the phosphorus be literally *absolute*; and in such case the preparation, if kept in well-filled and well-stopped bottles out of the light, will keep unaltered long enough for the treatment of an average case. If all the phosphorus be and remain dissolved, the solution contains 0.003 Gm. (one-twentieth of a grain, nearly) in four cubic centimetres (one fluidrachm)—a scant teaspoonful. The dose, averaging from one third to one small teaspoonful, is best taken clear, but if too sharp in that condition, may be taken in water, the mixture to be made only at the time of each administration.

Under no circumstances should phosphorus be prescribed as an ingredient of extemporaneous composite medicinal mixtures.

Zinc Phosphide: Zn_3P_2. A peculiar compound of phosphorus, which practically amounts to a medicinal preparation of the element itself, is what is officinal in the U. S. Pharmacopœia under the title *Zinci Phosphidum*, Phosphide of Zinc. This compound is prepared by direct union of its ingredients, and appears as "minutely crystalline, friable fragments, having a metallic lustre on the fractured surfaces, or a grayish-black powder, permanent in the air, having a faint odor and taste of phosphorus, insoluble in water or alcohol, but completely soluble in hydrochloric or sulphuric acids, with evolution of phosphoretted hydrogen. When strongly heated, with exclusion of air, the salt melts and is completely volatilized. If heated for some time in the air, it is partially converted into phosphate of zinc" (U. S. Ph.). Zinc phosphide must be kept in small glass-stopped vials.

This compound is lacking in the vigorously irritant action of phosphorus, yet, even in therapeutic doses, may easily upset the stomach and even excite vomiting. From its ready decomposition by acids it yields, in the stomach, some medicinally active condition of phosphorus, and its administration is therefore followed by similar therapeutic results to those attained by the use of the uncombined element. The phosphide is, however, not as certain as preparations of phosphorus itself, and is probably most commonly turned to as a last resort in cases where phosphorus persistently disagrees. Zinc phosphide contains one-fourth of its weight of phosphorus, and the dose therefore ranges from 0.003 Gm. (one-twentieth of a grain) to 0.016 Gm. (one-fourth of a grain). It may be given in pill-form, and, unlike phosphorus, this compound may be prescribed in combination with other medicines, avoiding only acids, which decompose it. After swallowing, however, the certainty of medicinal action will be enhanced by effecting this same decomposition through the agency of an acid draught, such as lemonade or a little vinegar. The most disagreeable features of the drug are a tendency to eructations of phosphoretted hydrogen and to disturbance of the stomach. With the larger of the doses mentioned above nausea is not at all unlikely. *Edward Curtis.*

[1] Wegner: Virchow's Archiv, June 22, 1872.

[2] See Phillips's Materia Medica and Therapeutics, Inorganic Substances, p. 51.

[3] Note on the Administration of Phosphorus, E. R. Squibb, M.D., Proceedings of the Am. Pharmaceutical Ass'n for 1876, and pamphlet, Philadelphia, 1877.

PHOSPHORUS, POISONING BY. Phosphorus assumes two allotropic modifications which differ widely from each other in their physical and chemical properties and in their physiological action.

1. Common phosphorus, when pure and recently made, is a colorless, transparent solid; but ordinarily it has a faint-yellow tint and is translucent. At low temperatures it is hard and brittle, but at ordinary temperatures it is soft, like wax, and at 44° C. melts, forming a pale-yellow, oily liquid. It is the most combustible of the elements. Heated in the air, it takes fire at a temperature of about 60° C., or even at much lower temperatures in the presence of certain oxidizing agents, and slowly combines with the oxygen of the air at the ordinary temperature. It is therefore always kept under water. It is luminous in the dark, and evolves fumes

* In calculating these metric equivalents regard has been paid to the specific gravities of the several fluids.

which possess a characteristic garlic-like odor. The luminosity is prevented by certain gases—for example, sulphuretted hydrogen—and by the vapors of certain liquids, such as ether, alcohol, turpentine, etc. Common phosphorus is nearly insoluble in water (100 grams of water at a temperature of 36° to 40° C., dissolve, according to Hartmann, 0.227 milligram phosphorus), slightly soluble in alcohol and ether, a little more soluble in fixed and volatile oils, especially with the aid of heat, and freely soluble in sulphurous chloride or carbon disulphide. It comes into the market in the form of cylindrical sticks. These, under the influence of air and light, become covered, when kept under water, with a white crystalline incrustation. Under the long-continued action of direct sunlight they become red.

2. Red or amorphous phosphorus is obtained by heating ordinary phosphorus to a temperature of about 240° C., in an atmosphere of carbon dioxide, or some other inert gas. It is a reddish-brown, amorphous powder, tasteless, odorless, and insoluble in those solvents which dissolve ordinary phosphorus. When pure, it is not ignited by friction, and may be heated in the air to 240° C. without taking fire; but at a slightly higher temperature it is reconverted to common phosphorus and inflames. While ordinary phosphorus is a powerful poison, red phosphorus, if pure, appears to be entirely destitute of poisonous properties (De Vry, Renault and Delafond, Caussé, Chevallier, and others).

Other allotropic modifications of phosphorus which have been described are unimportant in this connection. Of the compounds of phosphorus, phosphuretted hydrogen and phosphide of zinc are poisonous, but are not likely to become the subject of medico-legal investigation.

Phosphorus is employed chiefly in the manufacture of matches. These are tipped, first with sulphur, wax, or paraffin, and then with a mixture of phosphorus, an oxidizing agent, and frequently some coloring matter, made into a paste with glue. The phosphorus in the mixture usually amounts to six or seven per cent. Phosphorus also enters into the composition of many rat-pastes. These usually contain about one and one-half to four per cent. of phosphorus, mixed with such substances as meal, butter, sugar, etc. A comparatively small amount of phosphorus is used in medicine, in the laboratory, and in the preparation of a few important compounds.

Acute Poisoning.—Cases of acute phosphorus-poisoning have been very numerous in France, Germany, and Austria, since the year 1850. In England and in this country they have been comparatively rare, and chiefly suicidal or accidental; the latter occurring usually among children, as a result of sucking the ends of matches. Matches are the most frequent source of phosphorus-poisoning, whether accidental, suicidal, or criminal. In criminal and suicidal cases, the mixture obtained by soaking the ends in some article of drink, such as milk, tea, coffee, etc., is usually employed. Next to matches, rat-pastes have been the most frequent source of phosphorus-poisoning. Cases of poisoning by solutions of phosphorus (medicinal preparations) and by phosphorus in substance are recorded, but the number is small.

Symptoms.—The ingestion of a poisonous dose of phosphorus is usually followed by an immediate eructation of gas which has the peculiar, disagreeable taste of phosphorus, and which is luminous if viewed in the dark. This may be followed very soon by a sensation of heat in the throat, œsophagus, and stomach, and by nausea and vomiting. Usually, however, no severe symptoms make their appearance under five or six hours; sometimes not for twelve, eighteen, or twenty-four hours. The patient will then complain of a sensation of heat or pain in the region of the stomach, a general feeling of malaise, loss of appetite, and thirst. These are followed by nausea and vomiting. If the vomited matters contain phosphorus, they have a characteristic odor, and are luminous in the dark. The interior of the mouth and throat may be luminous if viewed in the dark; and luminosity of the breath has been observed. The odor of phosphorus is usually perceptible in the breath. If vomiting has taken place early, and the poison has thereby been completely removed from the stomach, or if the dose has been small, the patient may recover without experiencing any further symptoms. In severe cases of poisoning, however, frequent and violent vomiting lasts for a day or two; the vomitus consisting of mucus and bile, and occasionally containing blood. The pain spreads over the whole abdomen, which becomes tender to pressure. The stools may be normal; but there is generally diarrhœa, sometimes constipation. In some cases the fæces have the odor of phosphorus; and, if they contain particles of phosphorus, they are luminous in the dark. There is usually more or less febrile disturbance. The pulse and temperature do not, however, vary much from the normal during the first day or two, neither is there at this time much change in the character and quantity of the urine. At times, however, the amount of urine is diminished.

In a certain number of cases the symptoms just described are very severe, and are followed by collapse and death within a few hours. In the majority of fatal cases, however, the gastro-intestinal symptoms, with the exception of more or less pain, cease on the second or third day, and the patient is apparently convalescent; but after a day or two, usually on the third or fourth day after the ingestion of the poison, further symptoms make their appearance. These secondary symptoms vary greatly in their character and severity, and in the rapidity with which they lead to a fatal result. Jaundice is usually the first of these, and is rarely absent except in those cases which pursue a very rapid course. It usually appears first in the conjunctiva, and spreads with more or less rapidity over the whole body. With severe cases of jaundice there is urticaria. Enlargement of the liver can now be detected, and this organ usually continues to increase in size till death takes place, though occasionally, as death approaches, there is an apparent diminution in size. The abdominal pains increase and vomiting again comes on—the vomited matters frequently containing more or less blood. The stools may be normal, but are often diminished in frequency, and usually light colored. The pulse frequently rises to 120 or 130 beats per minute, but later it becomes weak and slow, and finally is scarcely perceptible. There is not usually much variation in the temperature. Lebert and Wyss have noticed a temperature as high as 41.9° C. shortly before death; and sometimes just before death there is a noticeable fall in the temperature—in one case to 31.2° C. (Battmann). This class of cases, in which the symptoms are chiefly irritant, is the most common. The patient in fatal cases dies usually in a state of coma.

In some cases of phosphorus-poisoning hæmorrhagic symptoms are very prominent. These comprise abundant bloody vomitings, bloody stools, and hæmorrhages from the nose, mouth, throat, uterus, etc. When pregnancy exists, abortion or miscarriage almost invariably takes place. The blood becomes fluid, and there are numerous extravasations beneath the skin and mucous membranes.

In another class of cases the effects of the poison may be manifested by nervous symptoms, such as severe headache, disturbances of sight and hearing, difficulty of speech, sensation of numbness or tingling in the limbs, dizziness, fainting, etc. There is great prostration. The patient falls into a state of stupor, and is aroused only with difficulty. A prominent symptom in this class of cases is delirium, which is usually mild, but occasionally of a violent character. The patient ultimately falls into a state of coma or collapse. Death may be preceded by convulsions.

Cases of phosphorus-poisoning are frequently divided into three classes according to the prevailing character of the symptoms. Symptoms characteristic of all these three forms may, however, be met with in the same case.

The urine is almost invariably affected in the later stages of phosphorus-poisoning. It is usually diminished in amount, and is albuminous. After jaundice has set in, it is colored a dark brown, or green, contains bile-pigments and bile-acids, and may contain an abundant

sediment composed of epithelium-cells, casts, and blood-corpuscles. Leucin and tyrosin are occasionally met with. Sarco-lactic acid appears to be a constant constituent. The urea is at times increased, at times diminished. Schultzen and Riess state that the urea frequently disappears just before death, and that a substance very similar to peptone appears in its place. Lebert and Wyss have observed cases of poisoning in which there was complete anuria, lasting for twenty-four hours or more.

In cases of phosphorus-poisoning, the phosphorus has been almost without exception introduced into the system by way of the stomach. Experiments on animals show that its effects are the same when introduced by other channels. Landerer relates a fatal case of poisoning caused by the introduction of the ends of matches into the rectum of a boy aged fifteen; and a case is reported in which the inhalation of the vapor of phosphorus caused death within a week.

Prognosis.—This is unfavorable. Cases characterized by severe symptoms almost always end fatally; while those which promise to pursue a mild course are by no means certain to terminate favorably. Of 76 cases collated by Falck, 42 ended fatally. Of 108 collated by Schraube, 90 terminated in death. Death may take place suddenly from collapse, but more commonly the patient falls into a state of coma, and death follows from gradual failure of the respiration and circulation. In cases in which the phosphorus acts chiefly on the blood, death may result from exhaustion caused by loss of blood. Exceptionally, very severe cases recover. The symptoms disappear very slowly, however, and recovery is usually not complete for several weeks. Paralyses of the extremities have been observed as sequels (Gallavardin, Bollinger, Oppolzer).

Fatal Period.—In more than sixty per cent. of the fatal cases, death has taken place in from two to six days. The shortest period recorded is half an hour (quoted by Dr. Habershon). In about ten per cent. of the cases thus far reported, death has taken place in from twelve to twenty four hours; in fifteen to twenty per cent., seven to fourteen days have elapsed before a fatal result has occurred. The most protracted case which we remember to have seen recorded is one related by Orfila, fatal on the seventeenth day.

Fatal Dose.—It is only exceptionally that the amount of phosphorus actually taken in cases of poisoning is known. The minimum fatal dose cannot therefore be stated with accuracy. It varies with the form in which the poison has been taken. Phosphorus in solution or in the finely divided form is much more active than phosphorus in substance. In the finely divided form, 0.065 gram (1 grain) or thereabout is usually considered a dangerous if not fatal dose for an adult. A much smaller quantity would prove fatal to a child. A case is recorded in which 7.5 milligrams (⅛ grain) proved fatal to an adult (Löbel). This is the smallest fatal dose recorded for an adult. Galtier quotes the case of a woman who took 60 milligrams, in divided doses, in four days; she died three days after the last dose of 30 milligrams. Doses of 15 to 60 milligrams have produced serious symptoms in adults. Kessler relates a case in which 20 milligrams was fatal in three or four hours to a child seven weeks old. Quantities not much exceeding 0.1 gram (1.5 grain) have proved fatal in several cases. On the other hand, recovery has taken place after large doses, probably as a result of early vomiting; for example, 2 grams (30.8 grains) in the form of paste (Macevan); the ends of five hundred matches, equal to rather less than 0.32 gram (5 grains) of phosphorus (quoted by Dr. Taylor); the ends of two thousand matches, estimated to contain 1.2 gram (18.5 grains) of phosphorus (Blaschko). The effects of a given number of matches, or of a given quantity of rat-paste, necessarily vary, since the amount of phosphorus contained in them is by no means constant. Gunning estimated the amount on the ends of ten different sorts of matches. It varied between 12 and 62 milligrams (average, 36.9 milligrams) for each one hundred ends. Sonnenschein states that the amount of phosphorus varies between 0.097 and 1.04 gram for each one hundred ends. The effects of matches will also vary according as the liquid in which they have been macerated is stirred or not as a preliminary to its ingestion. If it is not, the greater part of the phosphorus remains at the bottom of the vessel. Wharton and Stillé quote a case of a child, two and a half years of age, who died from swallowing the phosphorus contained on eight matches; and another case of a child, two months old, who was said to have died from the effects of two such matches. The phosphorus from one hundred matches has caused death in five days (Mering); while that from ten to fifty matches has produced severe symptoms.

Post-mortem Appearances.—Fatty degeneration of the liver, kidneys, heart, and epithelium of the gastric glands, enlargement of the liver, and hæmorrhages into the skin and serous and mucous membranes are the characteristic appearances observed in cases of phosphorus poisoning. Unless death has taken place early, there is almost always a yellow discoloration of the skin and conjunctivæ; and there are, in some cases, hæmorrhages into the skin. When the body is opened the odor of phosphorus may be perceived. There is usually nothing noticeable in the mouth, throat, and œsophagus. There may be evidences of local irritation in the stomach and intestines—such as redness and injection of the mucous membrane, and even ulcerations in rare cases. But these are more common in the rapidly fatal cases, and in any event are not constant. The mucous membrane of the stomach is swollen and cloudy, owing to fatty degeneration of the cells of the gastric glands (gastro-adenitis). The glands are swollen, and the cells filled with dark granular matter, and later with distinct fat-drops. The cells may ultimately break down and a granular detritus remain. Similar appearances may be observed in the intestines, especially in the duodenum. This degeneration is not due to the local action of the poison; for it is present when the phosphorus has been introduced into the system by other channels than the mouth. There may be hæmorrhages into the mucous membrane of the stomach and intestines. The contents of the stomach and intestines may be bloody, and, in cases of rapidly fatal poisoning, may have the odor of phosphorus and appear luminous if viewed in the dark. Fatty degeneration of the liver is a constant result of the action of phosphorus, and may be of a high grade within twelve or fifteen hours. This organ is usually very much enlarged and has a pale-yellow or deep-yellow color. Upon microscopical examination, the liver-cells throughout the whole lobule are found filled with minute fat-drops. According to some authorities there is an increase of the interstitial tissue and a proliferation of cells in this tissue. Other authorities have failed to observe any such appearance. That such a change takes place under the influence of small doses continued for some months is proven by Wegner's experiments on animals. Ecchymoses beneath the capsule of the liver, or along the course of the vessels, are observed in some cases. The kidneys are enlarged and yellow; the epithelium of the tubules highly granular or fatty. There may be ecchymoses beneath the capsule of the kidneys, and blood in the pelvis; ecchymoses beneath the mucous membrane of the bladder, and bloody urine in the bladder. The heart, muscles of the body, and the walls of the small vessels and capillaries are all in a state of fatty degeneration. Ecchymoses beneath the serous membranes, such as the pericardium, endocardium, and pleura, are common. The blood is usually dark and fluid. If death has taken place within a few hours, the appearances may be, for the most part, negative to the naked eye. It is probable, however, that a microscopical examination in such cases would furnish evidences of the early stages of fatty degeneration.

Physiological Action.—Various theories have been proposed in explanation of the poisonous action of phosphorus. The one which assumes that the phosphorus is oxidized in the system to phosphorous or phosphoric acid, and that the poisonous effects are due to these, is not satisfactory. These substances may, it is true, be formed, but their poisonous action is too slight to account for the symptoms. That phosphorus may be absorbed as such

is evident, since it is slightly soluble in water and still more soluble in certain animal fluids, especially the bile (Hartmann); and that it is absorbed in part as such is proven by its detection in the blood and liver (Husemann and Marmé, Bamberger, and others); and by the luminosity of the breath, observed in the case of animals poisoned by phosphorus which was introduced into the stomach, the œsophagus having been previously tied. Bamberger has also demonstrated that phosphorus is volatile at the temperature of the body and that its vapors pass through animal membranes. He also found that defibrinated blood, when separated from the vapors of phosphorus by an animal membrane, quickly becomes saturated with phosphorus.

Dyokowsky's experiments confirm the theory of Schuchardt, that phosphorus is converted into phosphuretted hydrogen either in the intestine or in the blood. Its action when in the blood is not, however, clear. The small quantity sufficient to cause death renders it probable that it does not act simply as a deoxidizer. It is certain that it interferes with the process of oxidation within the body, and that there is, at the same time, an increased decomposition of the albuminous substances in the body.

The presence of bile-acids in the urine shows that the jaundice is caused by the reabsorption of the bile, dependent on occlusion of the bile-ducts, and not by an arrest of the secretion. Kohts believes that the occlusion is usually due to duodenitis involving the common duct, while Wyss, Alter, and Ebstein believe that the jaundice is caused by a catarrhal inflammation of the minute gall-ducts. Riess states that he has never observed such inflammation. The hæmorrhages probably depend upon the fatty degeneration of the walls of the small blood-vessels and capillaries.

Treatment.—The first indication is to remove the poison from the stomach, if possible, and thus prevent its absorption. The stomach-pump should therefore be employed; or vomiting should be induced by emetics. As an emetic, sulphate of copper occupies the first place, since it not only acts as an emetic but also as an antidote. Phosphorus in contact with soluble salts of copper immediately becomes black, owing to the formation of phosphide of copper. This compound, according to Marmé and Husemann, has no injurious action. After vomiting has been induced, the sulphate should be administered frequently in such doses as the stomach will retain. Bamberger gives the carbonate of copper preference over the sulphate as the antidote. It should be administered in doses of 0.25 to 0.5 gram (gr. iv. ad viij.) every half-hour, with a little dilute acetic acid. If the poison has passed into the intestines a purgative, as magnesium sulphate, is demanded. All fats and fixed oils should be avoided, both as medicines and as foods, during the whole progress of the case, since phosphorus is soluble in these and its absorption is thus favored.

Oil of turpentine, which was first recommended by Andant in 1868 as an antidote in acute phosphorus-poisoning, has been used largely in experiments on animals, and with varying results. Experiments of Jonas, Vetter, and Köhler have demonstrated that the pure oil is not an antidote, but that the impure oil, which contains oxygen, is antidotal—first oxidizing the phosphorus and then converting it to a crystalline substance, called, by Köhler, turpentine-phosphorous acid. Köhler states that one part of the oil is more than sufficient to neutralize the effects of 0.01 part of phosphorus. Its administration should be continued for several days after the ingestion of the poison. Bamberger, however, claims that the copper salts are more efficient as an antidote, since their action is much more rapid than that of the oil of turpentine.

Eulenburg and Vohl have demonstrated that a solution of phosphorus in oil is deprived of all its phosphorus by filtration through animal charcoal. They therefore recommend the use of the latter as an antidote after vomiting has been induced. Thiernesse and Casse claim to have obtained good results, in experiments on animals, by the slow injection of oxygen into the veins; also, in cases of poisoning in man, by the internal administration of oxygenated water. After the poison has been absorbed the treatment must be wholly symptomatic.

Chemical Analysis.—The substances which should be submitted to analysis are: (1) During the life of the patient, the vomitus, fæces, urine, and suspected articles of food; (2) after death, the contents of the stomach and intestines, the blood, and the organs of the body—preferably the liver. The presence of phosphorus in organic mixtures may often be detected by the characteristic odor. This may, however, be concealed in the presence of certain substances, such as rum and coffee (Dannenberg), mustard, coffee, smoked meat, highly seasoned food and beverages, medicines containing odorous gum-resins, volatile oils, and camphor (Hoffman). According to Wormley, the odor was concealed when comparatively large amounts of the poison were added to animal mixtures which were undergoing putrefaction. The substances should be examined in regard to their luminosity in the dark. If putrefaction has commenced, they should be acidulated with dilute sulphuric acid, and, while under examination, should be stirred, with gentle heating. A careful examination should be made for particles of phosphorus. If found they are easily recognized by their physical appearance, odor, luminosity, inflammability, and chemical tests. If phosphorus has not been detected by this preliminary examination, some one or more of the following methods must be employed.

Scherer's reaction: This may be employed as a preliminary test. It is based upon the fact that free phosphorus, as well as phosphorous acid, decomposes silver-nitrate solution, with the production of phosphoric acid and metallic silver. The best method of employing this test, according to Hager, is the following: The suspected substances are mixed with a little basic acetate of lead solution, in order to neutralize any sulphuretted hydrogen which may be present; a portion of the mixture is then placed in a flask, and shaken vigorously with ether; the flask is then closed with a cork, to the under-surface of which is suspended a piece of paper moistened with silver-nitrate solution; the flask is then placed in a dark place. The paper will become blackened in from a few minutes to half an hour, even if the quantity of phosphorus present is very minute. Other vapors blacken silver-nitrate solution; the paper should therefore be digested with a small quantity of hot water, the silver separated from the solution by hydrochloric acid and filtration, and the filtrate, after concentration, tested for phosphoric acid. The paper employed must be free from phosphates. This reaction is, according to Dragendorff, so characteristic that, if obtained, there is no necessity for further examination.

Mitscherlich's Method: This is the most delicate method known for the detection of uncombined phosphorus. The suspected material, previously diluted with water if necessary, is acidulated with dilute sulphuric acid and distilled, the vapors evolved being conducted through a glass tube surrounded by a condenser. The vapors are condensed when they reach the cool part of the tube, and are luminous when viewed in the dark if phosphorus is present. The operation should be conducted in a dark room, and should be continued as long as any luminosity is visible. The residue in the flask is preserved for subsequent examination by the Dusart-Blondlot method. If the amount of phosphorus is not too minute, a portion of it collects in the receiver in the form of globules. A portion, however, always undergoes oxidation, and is found in the distillate as phosphorous acid. This oxidation is prevented if the acid mixture is heated in a flask through which a slow current of carbon dioxide is being passed. If the vapor of phosphorus is, under these circumstances, conducted into a solution of silver nitrate, the insoluble phosphide of silver and phosphoric acid are formed. If the phosphorus in the mixture to be examined has undergone oxidation the method of Mitscherlich will not serve for its detection; the substance must be examined for phosphorous acid by the method next described. The phosphide of silver obtained as just described, and the distillate containing phosphorous acid, may be examined in the same way. If the material to

be examined contains substances which prevent the luminosity of phosphorus, such as alcohol, ether, or oil of turpentine, no luminosity is perceived as long as these distil over. Alcohol and ether, being very volatile, soon pass over, and then the luminosity appears. The luminosity is, however, entirely prevented by oil of turpentine, and it is interfered with or prevented by salts of mercury, iodine, metallic sulphides in the presence of free sulphuric acid, and particularly oil of wormseed (Hoffmann). These substances do not interfere with the detection of phosphorus by the process to be described next.

Dusart-Blondlot Method: This is based upon the fact that free phosphorus, phosphorous acid, and the phosphides of silver and copper form, with nascent hydrogen, phosphuretted hydrogen, which burns with a green flame. For the separation of free phosphorus from the animal fluids and tissues, as a preliminary to this test, Dusart recommends the following process: The substance to be examined, the tissues being first finely divided, is treated with a mixture of alcohol, ether, and carbon disulphide, in which one half per cent. of sulphur has been previously dissolved. The mixture is added in sufficient quantity to form an emulsion. Any phosphorus present dissolves in the carbon disulphide, and, uniting with the sulphur, forms a compound of phosphorus and sulphur. After standing twenty four hours the carbon-disulphide mixture is decanted, and the residue treated a second and a third time in the same manner. The mixed carbon-disulphide liquids are quickly filtered into a retort, and metallic copper, recently reduced by hydrogen, is added in small portions until the last portion remains bright after warming the mixture for some minutes. After standing twenty four hours the mixture is heated on a water-bath till the carbon-disulphide mixture has distilled over. After the distillation there remains in the retort a little water, fatty and extractive matters, and the copper covered with the compound of sulphur and phosphorus.

The copper is collected on a filter, washed with alcohol, and then with ether; this removes the fat and leaves the copper compound as a black, brilliant substance, which is not perceptibly acted upon when exposed to the air. It may be preserved in the dark for any length of time.

In the application of the Dusart-Blondlot method the substance to be tested for free phosphorus or phosphorous acid, or the phosphide of silver or copper obtained as has been described, is placed in a flask in which pure hydrogen is being evolved by the action of dilute sulphuric acid on zinc. The escaping gases should be passed through a tube containing pumice-stone moistened with potassium hydrate, in order to absorb sulphuretted hydrogen, and the delivery-tube should be provided with a platinum point. The evolved gas, conducted into silver-nitrate solution, produces, if phosphuretted hydrogen is present, a precipitate of phosphide of silver; when ignited it burns with a characteristic green color.

Lipowitz's Method: This is based upon the fact that sulphur, when heated with free phosphorus, combines with the latter. The substance to be examined is acidulated slightly with sulphuric acid, and boiled for half an hour in a retort with a few small pieces of sulphur, the distillate being collected in the ordinary way. The pieces of sulphur are removed, washed, and examined with reference to their odor and luminosity in the dark. When they are treated with strong nitric acid, the phosphorus is oxidized to phosphoric acid, which may be recognized by appropriate tests. A portion of the phosphorus usually passes over into the distillate.

Bastelaer's Method: By this method the author claims that phosphorus, if present, can be separated in a state of purity, so that in medico-legal cases it can be taken into court as the *corpus delicti*. The substance, with the addition of water, if necessary, to render it sufficiently fluid, should be shaken with an equal volume of ether repeatedly for four or five hours, the ether decanted, and the process repeated with fresh ether two or three times. The united ethereal fluids should then be allowed to evaporate spontaneously, a little water being added toward the end of the evaporation in order to prevent contact of the phosphorus with the air. The aqueous liquid, after the evaporation of the ether, should then be warmed to 50 or 60 C., which will cause the particles of phosphorus to unite together in the form of a drop at the bottom of the vessel containing the water, while a large portion of the fat, which has been removed by the ether will float upon the surface of the water. Some of the fat, however, remains with the phosphorus, and can be separated from it by shaking with strong ammonia water several times. Then, by washing the phosphorus with dilute sulphuric acid, and finally with water, we obtain it perfectly pure, and with its characteristic physical and chemical properties.

If the phosphorus in the substances under examination has been oxidized to phosphoric acid, the methods described will fail to reveal its presence. The tests for this acid can be applied after the destruction of the organic matter. But in the absence of free phosphorus or phosphorous acid, the detection of phosphoric acid or phosphates, even in excess, cannot be considered proof of poisoning by phosphorus. Experiments which have been made to determine whether, under the influence of putrefactive processes, the phosphorus contained in animal and vegetable substances may be set free or converted to phosphuretted hydrogen, and thus vitiate the results of the chemical analysis, have thus far given negative results.

Failure to Detect the Poison.—In cases of suspected phosphorus poisoning the chemical analysis should always be made immediately. For phosphorus has a strong affinity for oxygen, and may very early become oxidized to phosphoric acid. In cases which have proved fatal in four or five days, there is often a failure to detect the poison, either because of such oxidation or because it has been rapidly eliminated. In some cases, on the other hand, phosphorus has been detected after comparatively long periods. Wharton and Stillé quote a case in which free phosphorus was detected in the contents of the intestine on the tenth day after it had been taken. Ludwig reports a case in which about one grain of phosphorus was obtained from the contents of the stomach and intestines three weeks after death. In a case reported by Elvers, one and a half grain was obtained from the intestines eight weeks and two days after death. Fischer and Müller, in experiments upon guinea-pigs poisoned with twenty-three milligrams (about one-third of a grain) of phosphorus, detected free phosphorus in the body at the end of eight weeks; phosphorous acid, but no free phosphorus, at the end of twelve weeks; phosphoric acid only at the end of fifteen weeks. A case is recently reported by Polcck, in which phosphorous acid, but no free phosphorus, was detected in the contents of the stomach and intestines, and in the heart, liver, kidneys, and brain, three months after death (*Archiv der Pharmacie*, March, 1887).

Quantitative Analysis.—Any phosphorus found in the solid state, or obtained by any of the methods employed (Mitscherlich's or Bastelaer's), should be weighed as such. Phosphorous acid should be converted to phosphoric acid by evaporation with a little nitric acid. The phosphorus may then be determined as magnesium pyrophosphate. One hundred parts of this compound correspond to twenty-eight parts of free phosphorus. The phosphoric acid may be more rapidly determined volumetrically by titration with a standard solution of uranium acetate. Works on quantitative analysis should be consulted for details.

Chronic Poisoning.—This is caused by the inhalation of the vapor of phosphorus, and is observed most frequently among workmen engaged in the manufacture of matches. The action of the poison is, in most cases, first manifested by loss of appetite, digestive disturbances, gradual emaciation, and possibly nausea, vomiting, and diarrhœa. There is frequently great irritation of the respiratory organs, chronic bronchitis being common. These effects may appear after a very slight exposure, but more frequently after the lapse of weeks or months.

The most important and characteristic result of the action of phosphorus-vapor is the disease of the jaw—the so-called phosphorus necrosis, which may appear within a few weeks after commencing work, or not for several months or years. It usually begins in carious teeth, and is hardly ever seen in persons with sound teeth. Toothache is usually the first symptom. The gums become swollen and spongy, abscesses may form from which an offensive pus issues, and finally, periostitis with subsequent necrosis of the jaw results. In severe cases the greater part or the whole of the jaw may be affected. The lower jaw is most frequently the one affected.

The necrosis of the jaw is due to the local irritant action of the vapor. Wegner's experiments on rabbits showed that necrosis never occurred unless the vapor of the phosphorus had access to the bone through a carious tooth, or an artificial wound. If, however, any bone was exposed to the action of the vapor, periostitis and necrosis resulted.

The disease may be prevented in great measure by securing good ventilation, and by excluding all workmen with unsound teeeth; and wholly prevented by substituting red phosphorus for ordinary phosphorus in the manufacture of matches.

If the bones are already affected, operative measures may be necessary. The disease is said to be much less frequent than formerly, owing to the precautions taken.

William B. Hills.

PHOTO-MICROGRAPHY IN MEDICINE. A photo-micrograph is an enlarged photographic image of a microscopic object. The term is now generally accepted by microscopists in this country and in England, but German authors commonly speak of such a picture as a micro-photograph. This has led to some confusion, as the latter term is used by English authors to designate a reduced photographic image of any object, made on so small a scale that a microscope is required to see it in a satisfactory way. Thus the Lord's Prayer has been photographed in a space no larger than a pin's head, etc. The micro-photograph is interesting as an exhibition of the capabilities of the art of photography, but otherwise has no special value. The photo-micrograph, on the other hand, is a record of what has been seen under the microscope, and may have considerable scientific value. Its special value arises from the fact that it is a record made by the sun, and that, consequently, it is free from the principal objection which may be urged against drawings of microscopic objects, viz., that they do not always represent exactly what has been seen under the microscope, but rather that to which the observer wishes to give special prominence, or that which he thinks ought to be present, and perhaps imagines that he has seen. In other words, the photo-micrograph rules out the personal equation of the observer.

It is well known to expert microscopists that the picture seen under the microscope may tell a different story to different observers, and that very remarkable misinterpretations of what is seen may be made by those who are not familiar with the use of the instrument, and even by those who have had considerable practice with it. The photo-micrograph enables us to interpret for ourselves the appearances which it records. It also enables us to form an estimate of the technical skill of the one who made it, and to decide, in some measure, how much weight we should give to his recorded observations. A novice in the use of the microscope may be quite skilful with his pen and pencil, and may make it appear that he has seen something quite novel and remarkable. After reading his statements and looking at his drawings, even an expert may be left in doubt as to the value of his observations. But if he makes a photo-micrograph in which an air-bubble or a pollen-grain which has accidentally fallen upon his preparation, or any other object with which microscopists are familiar, is pointed out as something new and curious, his illustration will at once show what value should be placed upon his observations. Again, if the photo-micrograph shows serious defects in the preparation of the object photographed, or in focusing the image, etc., the inexperience of the one who made it will be apparent.

But this will be apparent only to an expert who is familiar with the image of the same object as seen under the microscope. Just as the practised eye is needed to interpret properly the picture seen through the tube of the microscope, so also it is with the photographic image of this picture. Indeed, it requires even greater experience, for under the microscope we have sharper contrasts, and color pictures, and the opportunity to use the fine adjustment-screw, by which different planes in the field are brought successively into view. In a photo-micrograph one can only have a well-defined picture of that portion of the field of view which is perfectly in focus, while all details of structure which are not in focus, and all extraneous objects, serve to confuse the image, and to a certain extent destroy the value of the picture for any but an expert. The expert, on the other hand, is in the habit of disregarding extraneous objects and those portions of the field under the microscope which are not in perfect focus. Knowing the difficulty of obtaining ideal pictures of this kind, he may be content with the way in which the essential features are brought out in the photographic image, and will make due allowance for the technical difficulties which must be encountered by the conscientious observer who undertakes to furnish a sun-picture of the object or appearance to which he desires to call attention. But one who is not familiar with the picture as seen under the microscope, or with the difficulties attending the attempt to reproduce it by photography, is apt to be hypercritical. He prefers the sharply-drawn lines of a woodcut, such as he is familiar with in the text-books. He cannot overlook the indistinctness of that part of the field which is not in perfect focus; for him mammalian blood-corpuscles are always round, and if some of those seen in the photograph are more or less distorted, this constitutes a serious defect which offends his æsthetic sense. In short, he makes no allowance for the technical difficulties of which he has no knowledge, and demands such a picture as he is familiar with.

Photo-micrographs are, therefore, for the educated eye rather than for general purposes of illustration. A drawing which is diagrammatic, and which exaggerates the details to which special attention is called, may be more useful for the instruction of beginners than the most accurate photograph from nature. But in the use of such illustrations, care should be taken to point out the fact that they are diagrammatic, and to urge the student to seek the true appearance by direct observation of the object itself under the microscope.

What has been said is sufficient to show the desirability of substituting sun-pictures for those hand-made in the illustration of scientific works and memoirs in which original investigations are recorded. This is especially true with reference to medical science. The progress of our knowledge has been so much retarded by erroneous observations and the misinterpretation of what has been seen under the microscope, that it is extremely desirable that, so far as practicable, discoveries in this department of science may be demonstrated by photographs from nature.

But, while there is no question as to the desirability of such a record, the technical difficulties attending the production of satisfactory photo-micrographs have, up to the present time, greatly restricted the application of this mode of illustration. The cost of reproducing such pictures has likewise interfered to a considerable extent with their extended use. As I shall point out hereafter, the technical difficulties have been considerably reduced by recent improvements in optical appliances and in photographic methods; and the recent invention of cheaper methods of reproducing photographs from nature opens an extended field of usefulness for this art.

The pioneer work of the lamented surgeon, J. J. Woodward, of the United States Army, of Dr. R. L. Maddox, of England, of Dr. Robert Koch, of Germany, and of many others who have devoted more or less time to this fascinating art, has cleared many of the difficul-

ties from the way of those who may be inclined to take it up hereafter.

I shall not attempt in the present article to give any details with reference to photographic methods and manipulations. They do not differ from those used in ordinary photographic work and may be acquired most readily under the personal instruction of an expert photographer.

Attempts were made to photograph microscopic objects by transmitted light soon after the methods of photography became generally known, but, owing to the causes heretofore referred to, the application of this method to the illustration of scientific memoirs has been quite limited. As examples of what has been accomplished in this direction, the reader is referred to Koch's photographs of bacteria in Cohn's *Beiträge zur Biologie der Pflanzen*, vol. ii., 1877; to the photo micrographs by the same author in the *Mittheilungen aus dem Kaiserlichen Gesundheitsamte*, 1881; to those of Dr. R. T. Maddox in the *Journal of the Royal Microscopical Society* (December, 1882); to the photo-micrographs of the cholera spirillum —so-called "comma-bacillus"—which illustrate the work of Van Ermengem, "Le Microbe du Choléra Asiatique," 1885; to the memoir of Hauser, "Ueber Fäulnissbacterien," 1885; and to the writer's photo-micrographs in various published papers, in "Photo-micrographs and How to Make Them" (Osgood & Co., Boston, 1883), now out of print, and in "Bacteria" (William Wood & Co., New York, 1883).

Especial attention is called to Plates VIII. and X. in the second edition (1884) of the work last mentioned. Figs. 2 and 5 of Plate VIII. represent the anthrax bacillus as seen in the liver and in the kidney of an inoculated animal which succumbed to the disease. These may be taken as fair samples of what can be done in the way of photographing bacteria in very thin, well-stained sections of tissues. Fig. 1 of the same plate corresponds with Fig. 6 of the plate illustrating the present article, and gives an opportunity to compare the merits of two different methods of reproducing a picture from the same negative. The plate in "Bacteria" is printed from my negatives by the heliotype process; the plate in the present volume was made by what is known as the "direct process." Silver prints of my photo-micrographs, selected for this plate, were sent to the publishers of the Handbook, and the result, as shown in the plate, is extremely satisfactory. As no handwork comes in, in either process, the figures as printed are free from the objection which attaches to hand-made pictures, and represent exactly what was in the field of the microscope when the original negative was taken. In Plate X. of the volume referred to, photographs of the blood of yellow fever patients, reproduced by the heliotype process, may be compared with Figs. 1 and 2 of Plate XXV. of the present volume, which are from the same source, although not from the same negatives.

The Possibilities and Limitations of the Art of Photo-micrography.—When it was demonstrated by Woodward and others that it is possible to make satisfactory photo-micrographs of the enlarged image of certain microscopic objects, many microscopists jumped at the conclusion that the pictures with which they were familiar under the microscope could be photographed without difficulty, and that for the permanent record of such pictures it was only necessary to possess certain apparatus, and to become familiar with the processes employed in photography. In this country Woodward's beautiful pictures of difficult test-diatoms, and of blood-corpuscles, were taken as fair samples of what might be expected from the new and fascinating art. But as a matter of fact, diatoms and blood-corpuscles are among the objects which are best suited for photographing by transmitted light, while, on the other hand, it is quite impossible to make a satisfactory photograph of many microscopic objects which give a most beautiful picture under the microscope.

It is essential, in the first place, that the object shall have a certain transparency for the actinic rays of light, otherwise these rays are completely arrested and we shall have no picture at all, or a picture in which the object is simply outlined by the effect of the light which has fallen upon the plate around it. If, for example, red blood-corpuscles spread out in a uniform layer on a cover-glass were the objects to be photographed, and if these were of so intense an orange-color that no actinic light could pass through them, the photograph would simply show circular patches, destitute of detail, and outlined by the effect of the light on that portion of the field not occupied by these bodies. If, on the other hand, these corpuscles were perfectly transparent, or were of a violet color, making them transparent for the violet rays, they would not appear at all, or would give only a faint and unsatisfactory image. But, as a matter of fact, the color of the corpuscles is such as to make them very suitable objects for photographing by transmitted light. They have sufficient color to arrest a considerable portion of the actinic light, and thus to give a good contrast with the background, and at the same time sufficient actinic light passes through them to show their true form (see Figs. 1 and 2, Plate XXV.). In the nucleated corpuscles of birds and reptiles the nuclei are well brought out in a properly exposed negative. The beginner is advised to practise upon blood-corpuscles before attempting more difficult subjects. They should be spread in a uniform layer on a cover-glass and allowed to dry. The cover is then mounted over a thin circle of cement and the preparation may be preserved indefinitely. I have found the best method of spreading blood to be that recommended by Woodward. A very small drop is placed upon one side of the cover-glass, lying flat upon a sheet of paper, and the end of a glass slide is drawn gently over the cover in the direction in which it is desired to spread the blood. No pressure can be used, as this destroys the corpuscles. The glass slide should be held gently almost in a horizontal position. By this method, after a little practice, beautiful fields may be obtained, in which the corpuscles are free from distortion and are separated from each other, lying flat in a single plane. The method often recommended, of sliding two cover-glasses over each other, does not give anything like as good results.

Refraction.—In the absence of color, details of structure are often brought out under the microscope by differences in the refracting power of different portions of the object. Such details also appear in the photographic image and give very satisfactory pictures. Take for example the white blood-corpuscle in the centre of Fig. 2, Plate XXV. This has no color, but nevertheless is well outlined, and a certain amount of detail may be seen in the granular protoplasm (not so much in the figure as here reproduced as in silver prints from the original negative). The four black dots seen in the interior of this corpuscle might be taken for the spores of some bacillus. They are in fact fat-granules (see article on Yellow Fever to be contributed by the writer in a subsequent volume of the Handbook). These fat granules have no color and are quite transparent, but they refract light strongly and make a sharp contrast in the photographic image. In the same way structure details are brought out in tissues where the cells or other histological elements are sharply outlined in the picture as seen under the microscope. The fine details in the frustules of difficult test-diatoms are brought to view in the same way, and wherever these details are visible they may be photographed. Indeed, it is possible to photograph details which are not to be detected by the eye, or at least to show clearly in the photographic image that which can only be detected with difficulty by the trained eye of the expert. Thus Koch has photographed the flagellum of a bacillus, although many microscopists have searched in vain for this extremely attenuated, whip-like appendage, the presence of which had previously been suspected, and even detected, by one or more skilled observers. We may illustrate the mode in which an image of transparent objects is formed, by differences in the refraction of light alone, as follows: If some pounded glass be placed in water and looked at through the microscope, the angular fragments will be plainly seen, with all of the

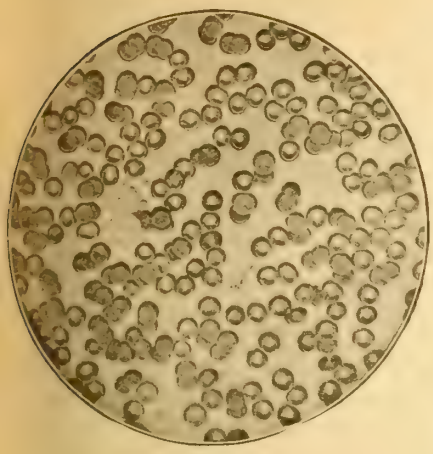

Fig. 1.

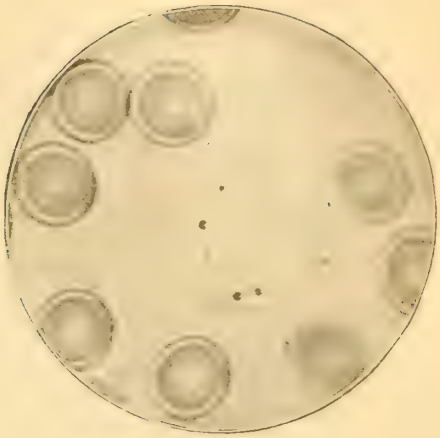

Fig. 2.

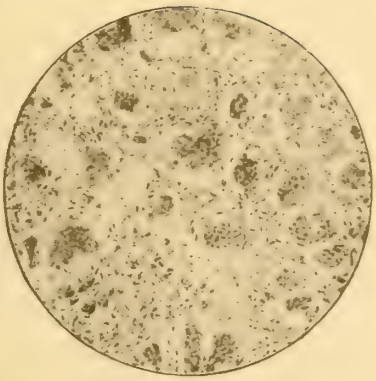

Fig. 7.

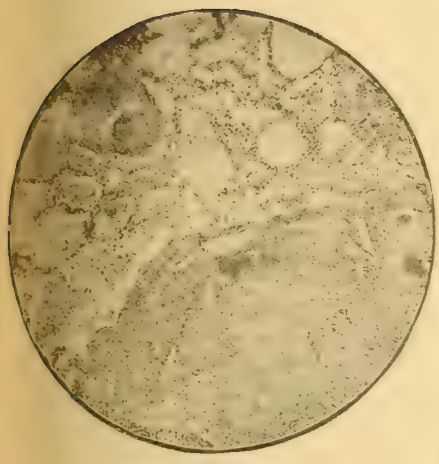

Fig. 3.

Fig. 4.

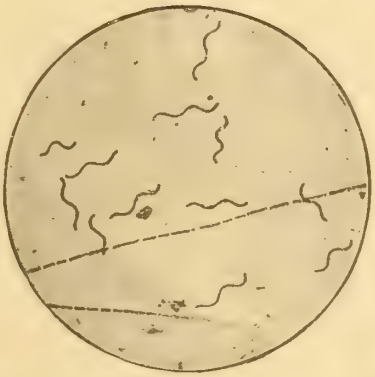

Fig. 8.

Fig. 5.

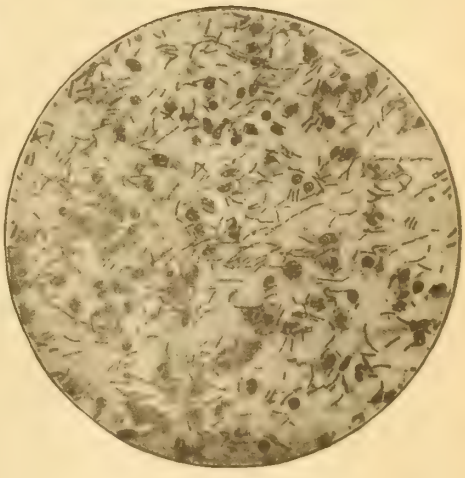

Fig. 6.

SPECIMENS OF MICROPHOTOGRAPHS.

(G. M. STERNBERG, M.D., U.S.A.)

details relating to their form. But if we mount the same fragments in a fluid having the same refractive index as that of glass, they will no longer be visible. The refractive index of the bits of glass and of the fluid which surrounds them being the same, the light passes through without being refracted at all, just as it would through a homogeneous transparent fluid or solid, and no image is formed upon the retina or upon a sensitized plate.

Color.—We may say in general that:

(*a*) Opaque objects cannot be photographed by transmitted light.

(*b*) Objects which are opaque for the actinic rays cannot be photographed by transmitted light; this includes all objects having a deep orange or red color.

(*c*) Objects which are transparent for the actinic rays, or nearly so, give a feeble photographic image or none at all, on account of the want of contrast in the impression made upon a sensitive plate; therefore, objects stained in violet or blue are not suited for photography.

In the preparation of objects for the microscope, we often have it in our power, by the use of staining agents, to give just the color which will give the best photographic results, and success in making photo-micrographs will depend largely upon the skill of the preparator, and his appreciation of the requirements for this special purpose. A brown color, such as may be obtained by staining the nuclei of tissue-elements with the aniline colors known as Bismarck brown, or vesuvin, is the most suitable when not too intense. The exact depth of color which will give the best results can only be learned by experience. In the case of objects which naturally have a deep brown, yellow, or orange color, it will be impossible to obtain a satisfactory photograph when this exceeds a certain degree of intensity. By a recent improvement in photography, however, it is now possible to photograph objects stained in these colors, which would have been quite opaque for rays capable of acting upon sensitive plates as they were formerly prepared. The so-called *isochromatic plates* are more sensitive to the less refrangible rays at the red end of the spectrum, and therefore better adapted for objects stained in red or orange. This result is obtained by the addition of azalin, or of eosin, to the emulsion used in making the plates.

In connection with these isochromatic plates *colored screens* may be used, which filter out the more refrangible rays and thus enable the operator to make an exposure long enough to obtain a good photographic image from the rays having less actinic power which are permitted to reach the plate. The eosin plates are said to possess astonishing sensitiveness, but they can only be kept for a few days. It is, therefore, advisable for those who intend using these plates to prepare them for themselves. The following directions are given by Professor Vogel in a recent number of the *Photographische Mittheilungen*, published in Berlin.

"Obernetter's recipe is as follows: Wash the plate for a minute with distilled water; allow it to drain; pour over it for one minute a solution of fluoride of silver (1 to 2,000); wash and pour over three times, in different directions, a solution of erythrosin-azalin (25 c.c. of a 1 to 1,000 solution of erythrosin, 2 c.c. of solution of commercial azalin, 50 c.c. of a solution of carbonate of ammonia (1 to 6), 1,000 c.c. of water); allow this to run off and dry the plate" (*op. cit.*, December 1, 1886, p. 228).

In a previous number of the journal referred to, Professor Vogel gives the following directions for the preparation of eosin-silver:

"Two years ago I made a thorough study with reference to eosin-silver, which is formed by adding a solution of silver to one of eosin, and I showed that this preparation is the basis of the color-sensibility of eosin-collodion wet-plates, and that the same, also in the dry-plate process, gives a considerably greater sensitiveness than is obtained by the use of eosin alone. . . . Add two drops of a silver solution of 1 to 10 to 4 c.c. of eosin solution of 1 to 40. Dissolve the precipitate by the addition of two drops of ammonia." Four drops of this solution are to be added to 10 c.c. of the emulsion, and it is said that the sensitiveness to yellow is increased ten times more than by the use of eosin alone. The following directions are given by Vogel for the use of rose bengal (tetraiodichlorfluoresceinsodium).

"Take, for example, 10 c.c. of a solution of 1 to 1,000 of rose bengal, of eosin, or of erythrosin; add 3 c.c. of a 1 to 1,000 solution of silver, 1 c.c. of ammonia; dilute with water to 50–100 c.c.; bathe the plates in this solution for one minute and dry them." These plates should be used within four days. Preference is given to rose bengal of Paris manufacture over that made in Berlin.

On another page of the *Mittheilungen*, the following formula is given for the development of eosin plates:

"As the most suitable developer for eosin-silver plates we recommend the pyro-soda developer according to the following recipe of Sachs:

Solution I.

Distilled Water	500 grams.
Neutral sulphate of soda	100 "
Pyrogallic acid.	14 "

Solution II.

Distilled water	1,000 grams.
Carbonate of soda	50 "

"In using, mix one part of No. I. with two parts of No. II."

Colored screens may be used with these specially prepared plates or independently of them. Several observers have reported success in photographing the tubercle-bacillus, when stained with fuchsin, by the interposition of a plate of green glass back of the object. As such a plate cuts off a considerable portion of the actinic rays, the time of exposure must be considerably lengthened. By this means also objects stained with hæmatoxylin, methylene blue, or gentian violet may be successfully photographed. A sufficiently strong photographic contrast is thus obtained, and details are brought out which would be quite lost if the attempt were made to photograph such objects by unfiltered sunlight. Experience shows that a screen of green glass is most useful for this purpose. This arrests a considerable portion of the actinic rays, without being entirely opaque for them, as a plate of orange or red glass would be.

Difficulties Resulting from Limited Focal Range.—The eye is an optical instrument which automatically adjusts itself with reference to the intensity of light and the distance of the object viewed. The result is that when we have a near object in view and perfectly defined, we may, in an instant, have an equally clear picture of a distant object toward which we direct our glance. But the photographer's lens has no such automatic adjustment, and to obtain well-defined pictures we must resort to the use of diaphragms, and must carefully focus the image in the field of view on the ground-glass screen. When the field of view includes objects at different distances, as in landscape photography, the photographer finds it difficult to obtain a picture in which all parts of the field are equally well defined. The proper focus for an object in the foreground is not the best focus for a distant object. Lenses are specially constructed to overcome this difficulty as far as possible. But in landscape photography this difficulty is trifling as compared with the difficulty arising from the same cause in photo-micrography. In the one case we have, projected upon a plane surface, the greatly reduced image of the objects in the field of view, by a lens of comparatively long focal range. In the other case we have a greatly enlarged image of the objects in the field of view, and any defect in the picture is exaggerated in proportion to the amplification, while the focal distance of the objective is often only a fraction of an inch. Objectives of high power have necessarily a very short "working distance," and in wide-angled immersion lenses this is reduced to a minimum. The result is that such lenses have very little *penetrating power*. That is to say, their focal range is extremely limited, and to be well defined objects must be exactly in the plane for which focal adjustment has been made. Anything

in the field of view which is not exactly in this plane becomes a source of confusion, and mars the picture when a photo micrograph is made. In the examination of specimens under the microscope this difficulty is overcome by focusing up and down by means of the fine adjustment screw. An expert microscopist does this unconsciously. If for example he has a preparation showing in the field of view cells and stained bacilli, he would ascertain whether the bacilli were in the cells, or in front of them, or behind them by carefully focusing first upon the bacilli themselves and then upon the cells, and considering whether they were in the same plane or otherwise. In making a photo-micrograph we cannot resort to this expedient, and if the bacilli and cells are in different planes, one or the other will be out of focus, and a source of confusion when we have carefully focused to give a picture of the particular element we wish to photograph. This difficulty is to be overcome by using objectives for photography which have as great penetrating power as possible, and by making our sections of tissues etc., as thin as possible, so that the histological elements are as nearly as may be in a single plane. The first object will be best attained by using objectives of comparatively low power, and obtaining the desired amplification by removing our screen to a sufficient distance from the object. There are, however, limitations in this direction which will be referred to hereafter. Owing to the very slight penetrating power of modern high-power objectives with very great angular aperture, they are not well adapted for photography except for objects which have no appreciable thickness, and which are uniformly distributed in a single plane. The resolving power of these objectives makes them useful for certain purposes, but the histological elements of animal and vegetable tissues are well brought out by objectives of comparatively low power and moderate angular aperture, which possess an immense advantage for photo-micrography on account of their greater penetrating power and considerable working distance.

The blood-corpuscles in Fig. 1 of Plate XXV. were photographed by means of a one-fifth inch objective (dry) of Beck, made at least ten years ago. The corpuscles in Fig. 2 were photographed with a one-eighteenth inch homogeneous oil-immersion objective of Zeiss. The superior penetrating power of the one-fifth inch objective is shown by the way in which the outlines of corpuscles are brought out to show their thickness, and especially in the overlying corpuscles. If our low-power lens does not give us the amplification we desire, we may make an *enlarged negative* from the original. Such an enlarged negative will, of course, not show any details not in the original picture, and there will be some loss in sharpness of outline; while defects will become more prominent in the enlarged picture as well as in the objects it is intended to show. For this reason only a first-class negative will bear enlargement, and, as a general rule, an amplification of two to five diameters will be about the limit attainable in a satisfactory manner. From what has been said, it is evident that it will be best to use objectives of as low a power as will suffice to bring out the details of the picture. We may, to some extent, attain the same object by placing a diaphragm before the front lens of an objective of higher power. The definition and the amount of light admitted to the screen will be diminished by the use of such a diaphragm, but the penetrating power of the lens will be increased.

M. Villanes has proposed to overcome the difficulty due to want of penetrating power by making *successive exposures* with different planes in focus. This author says:

"This method is based upon the fact that the same sensitive plate may receive two or more images without confusion; this may be shown as follows: Place on the stage a micrometer, bring its divisions to a focus on the ground glass, then insert the sensitive plate and expose for, say two minutes. Intercept the light, rotate the micrometer through an angle, and expose again for two minutes. The plate when developed will show two crossed images of the micrometer, which are perfectly clear even at the point where they intersect. In this way three, or even four, superimposed images may be obtained upon the same plate. From the observation of these facts I was led to use the method of successive exposures in the case of objects which could not be simultaneously focused in all their parts. If the same plate receives in succession the images of the different planes of an object, these will be superposed without confusion, and a compound image will be produced which is far more complete than that obtained by photographing in a single plane. In employing this method the head of the micrometer screw should be provided with an index which moves upon a graduated circle (see Fig. 2870).

The lowest part of the object being first brought to a focus upon the ground glass, the division at which the

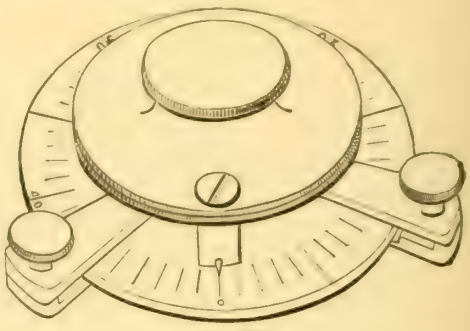

Fig. 2870.

index stands is noted, then the highest part of the object is focused, and a second reading is made on the circle. These readings determine the limits between which the index must move if all the successive planes of the object are to be photographed. The sensitive plate is now introduced and exposed three or four times, the index being set at different points between the limits; in this way three or four images are superposed and form a complete picture. To obviate the reading of angles the circle is provided with two movable stops which can be fixed at the limiting positions by means of screw-clamps, so as to limit the angular space through which the index can be turned without the necessity of any reading. In practice it is best not to attempt to obtain more than two or three successive impressions, since with a greater number the figure becomes confused. It must be added that the photographs are never as fine as those got from an object which can be completely photographed by a single exposure" (*Journal of the Royal Mic. Soc.*, June, 1886, p. 498).

Light.—*Sunlight.*—As light from some source is essential in photography, the question as to what source of illumination is best under various circumstances is one of prime importance. Sunlight commends itself by the fact that it costs nothing, and is entirely satisfactory for our purpose when we can have it. But those who have had much practice in making photo micrographs with high powers, know how uncertain this source of illumination is in some parts of the world. When we use a heliostat the sun must be entirely unveiled, in order to give us an image upon the screen. A fleecy cloud obscuring the sun's face for a moment practically puts out our light. When the sky is overcast we say, "this is not a good day for making photo-micrographs," and we occupy our time in some other way. But when the sky is clear, and we congratulate ourselves that we shall have a fine day for our work, we are often disappointed by the subsequent appearance of fleeting clouds, which scarcely interfere with the brightness of the sky, and yet suffice to interrupt our work in a most tantalizing manner. Led on by the hope that it will soon clear up entirely, we take advantage of a gleam of light from the eye of our condensing lens and endeavor to focus upon the screen the scarcely visible image of some minute object. Perhaps it is only after repeated attempts, inter-

rupted by the fading out of our light, that we get our image satisfactorily in focus. And now comes the exposure. In the time of wet plates I have often put my plate in the silver bath when the sun was shining brightly, and have got it into the plate-holder just in time to see the image fade out upon the ground-glass screen. Perhaps the sun would come out again and the shutter be drawn for an exposure, only to see the light again fade away before the necessary time of exposure had expired. Again, the plate would remain, waiting for the sun, until it was too dry for use. With dry plates, which require a shorter exposure, and are always ready, this difficulty is greatly modified. Woodward, speaking of this uncertainty of sunlight for making photo-micrographs, says:

"During the last week of October and the first two weeks of November, I relied wholly upon the sun as a source of illumination for producing negatives. In this period, during which I had but two perfectly cloudless working days, and several fractional days on which my work was continually interrupted by passing clouds, I had ample opportunity to convince myself that the uncertainty of the weather was a most serious hindrance to the preparation of successful photographs of microscopic objects, and I ceased to wonder that European microscopists, who are exposed to a climate even more variable than our own, have not yet succeeded in placing the art of photo-micrography upon such a basis as to make it a convenient and habitual auxiliary in all microscopical investigations."[1]

In addition to the uncertainty arising from cloudy weather, which is an element differing greatly at different seasons and in different localities, we have to contend with the fact that the sun is only available for use with a heliostat for a limited time during each day, and that this time is greatly restricted in our latitude during the winter months. In the early morning and in the evening the light cannot be utilized. The actinic power of the light rapidly fails after five o'clock in the evening, and a hazy condition of the atmosphere is very unfavorable for photographic work. Besides this, we are further restricted by the fact that the sun is so low in the heavens that our heliostat mirror only gives a narrow line of reflected light, which it is difficult to utilize. Notwithstanding these drawbacks, the light of the sun is likely to be the main reliance of those who are located in latitudes where bright days may be depended upon for a considerable portion of the year. Thus the writer found in Havana, in 1879, and in San Francisco, in 1881–83, that the clear sky and the very great actinic power of the light enabled him to use his heliostat with a degree of satisfaction which compensated, to some extent, for the many disappointments experienced in similar attempts, made during the winter months in the cities of Baltimore and Washington.

For low powers, where no heliostat is required, sunlight is available even when the sun is partly obscured by clouds. Full directions will be given later for making photo-micrographs with an amplification of five to ten diameters by the use of a photographer's lens and diffused sunlight.

The Electric Light.—The writer has had no personal experience in the use of the electric light, but recognizes the value of a light which can be brought into use at a moment's notice, especially for those who are prevented by other occupations from making photo-micrographs during the hours when sunlight is available. Surgeon J. J. Woodward, in his report to the Surgeon General of the Army already referred to, gives the following account of his experience in the use of the electric light.

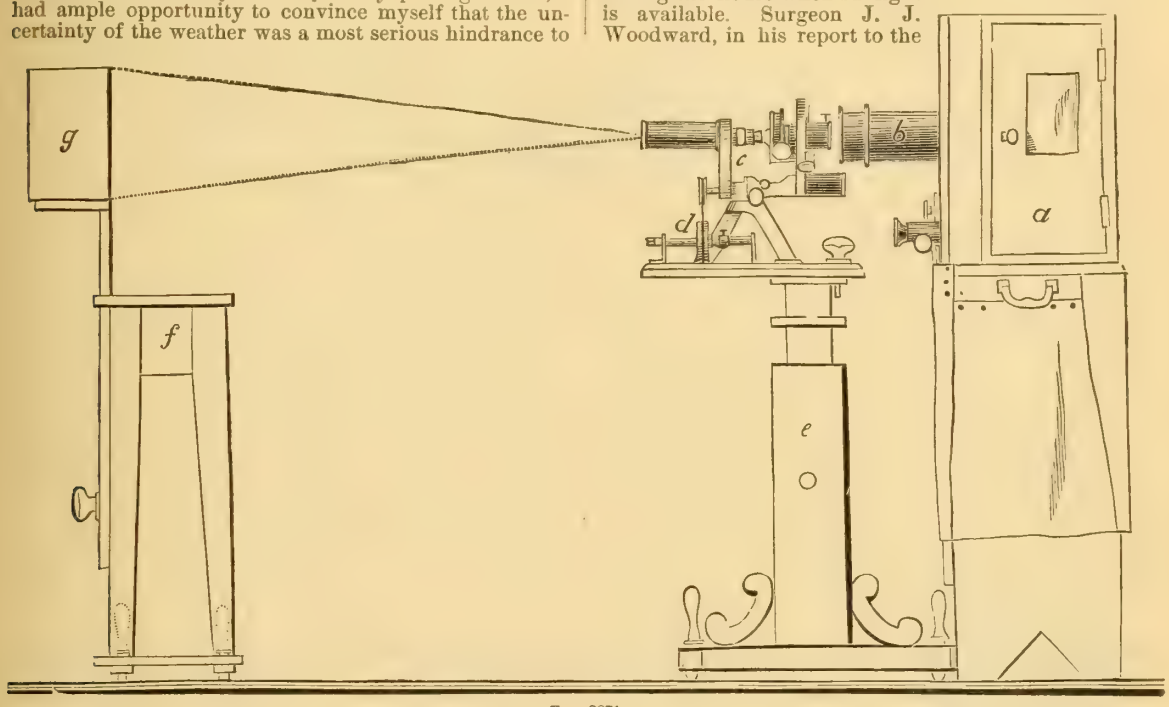

Fig. 2871.

"For the production of the electric light I used a Duboscq lamp, set in motion by a battery of fifty small Grove elements. I found that with this source of light photographs could be successfully taken with any power with which pictures can be taken by sunlight; and I was delighted to find, as I had anticipated, that the very exaggeration of light and shadow which has prevented the electric light from being generally adopted as a source of illumination in the preparation of photographs of the size of the object or smaller, proved of immense advantage in the reproduction of the feeble microscopical images of highly magnified objects, and that the pictures were hence clearer and better defined than any photographs of similar objects I had hitherto produced by sunlight. I found also that the electric light was so much more manageable than sunlight, as a source of illumination, that I could readily arrange it to produce negatives with much shorter exposures than are indispensable with the sun. . . . The electric light is by far the best of all artificial lights for the production of photo-micro-

graphs, and when used as I am now about to describe it is both convenient and economical. I use a Grove battery of fifty elements. The battery is placed just outside of the operating room, in a closet from which the fumes escape through an earthen pipe into the main chimney of the building. This battery was furnished by Mr. William Ladd, Nos. 11 and 12 Beck Street, Regent Street, London, W. The rubber cups are 4½ inches high, 3½ wide, and 2 thick. The platinums are 5½ inches by 2¼, and weigh about 60 grains each. The zincs are bent upon themselves so as to present a part of their surface on each side of the platinums and weigh, when new, about a pound apiece. Mr. Ladd furnishes these batteries in trays of ten elements, at five pounds sterling per tray, and I find that a battery of five trays is sufficient for most purposes. Seven pounds and a half of strong commercial nitric acid, and three of sulphuric, diluted with ten times the quantity of water, is sufficient to charge this battery, which will then produce the light continuously for from three to four hours. The cost of running the battery for this time, including in the estimate the amount of zinc consumed and the cost of amalgamating every third or fourth time of using, is very moderate. .

"The Duboscq lamp, the microscope, and the plate-holder are arranged in a dark room, which enables me to dispense with the use of a camera. The general arrangement of the apparatus is shown in the cut (Fig. 2871).

"The electric lamp of Duboscq (*a*) is placed on a stool against the wall at one end of the room, and its light concentrated by a pair of condensing lenses (*b*) on the lower lens of the achromatic condenser of the microscope. The microscope (*c*) (a large Powell & Lealand's stand) is placed on a small table (*e*) which is so arranged that it can be lowered or elevated at pleasure, and can be levelled by means of three levelling screws at its base. The plate-holder (*g*), also arranged so that it can be raised or lowered at pleasure, is supported by a small table (*f*) which stands on three levelling screws. The floor of the apartment is quite level.

"In taking photographs with this apparatus I proceed as follows: The electric lamp being set in motion, the table holding the microscope (which has previously been levelled) is raised or lowered and moved from side to side till the centre of the achromatic condenser is brought to the centre of the illuminating pencil proceeding from the lamp; the object is then placed on the stage and carefully adjusted. A cell of plate-glass containing a saturated solution of ammonio-sulphate of copper is fixed just below the achromatic condenser, and not only prevents the admission of non-actinic rays, but excludes the very great heat which accompanies the electric light, and also moderates its effect upon the eye of the observer. The light thus produced is very agreeable to the eye, and I find myself able to work with it from four to five hours without fatigue. It also has the advantage that all the colors of the object examined disappear, and the preparation appears black on an azure field, which resembles the sky on a clear day, so that the observer sees at a glance how the object will appear in the photograph, and is thus enabled to arrange his achromatic condenser and other adjustments so as to produce the most satisfactory effect." (*op. cit.*).

Notwithstanding the very favorable opinion of the electric light which Woodward had formed at the time this report was written, most of his subsequent work was done by sunlight, and I imagine that this may have been largely due to the fact that the care of a Grove battery of fifty cells involved more trouble and expense than was at first anticipated. At the present day it will be possible to obtain the electric light in many of our cities without the trouble and expense of caring for a battery, since there are "plants" for producing electricity for purposes of illumination by means of dynamo-electric machines.

The Magnesium Light.—Woodward also experimented with the magnesium light, and states his conclusions as follows:

"The magnesium light affords a beautiful source of illumination, comparable to white cloud illumination of the best character, or to the light of the sun after it has passed through a sheet of ground glass. Without the use of ground glass this light serves admirably for the production of photographs of the soft tissues with any power under a thousand diameters. The light being composed of a mixed pencil, with rays passing in all directions, there are no interference phenomena; but for the same reason, on the Noberts plate and many test objects, the results are inferior to those produced by the sun, or by the electric light; with powers much higher than a thousand diameters, however, the time of exposure becomes inconveniently long." (This was written before dry plates had come into use.) "The process employed by me in the production of negatives with the magnesium light, is essentially the same as I have above described for the electric light, simply the magnesium lamp is substituted for the electric, and the condenser of an ordinary oxy-calcium magic-lantern is made to concentrate the light on the achromatic condenser of the microscope." . . .

"The magnesium lamp used by me for this purpose was the two-ribbon lamp of the American Magnesium Co. (No. 2 Liberty Square, Boston, Mass.), sold by that company for magic-lantern purposes, price $50. The ribbon weighs about fifty-two centigrammes per metre, and is sold at $2.50 per ounce. Two ounces will, with care, answer for three or four hours' constant work, and ought to produce from twelve to thirty negatives, in accordance with the difficulties of the subjects to be represented. The fumes of magnesia resulting from the combustion are carried into a chimney, five feet long, made of spiral wire covered with muslin, which terminates in a muslin bag in which the oxide condenses, while the draft goes on through the interstices of the muslin. The chimney and bag are furnished by the company for $2.50.

"In commenting upon the above processes it may be remarked that for the anatomist and physiological investigator, the magnesium lamp affords a satisfactory and sufficient source of illumination for the photography of normal and pathological tissue-preparations. The same end will be equally well, or even better, attained with the electric lamp, with which also the most difficult test objects can be satisfactorily reproduced. Where economy of apparatus is the object the magnesium lamp will be preferred by ordinary workers; but where much work is done, the high price of the magnesium ribbon more than counterbalances the cheapness of the apparatus, and the electric light becomes the most economical" (*op. cit.*).

The price of magnesium has been greatly reduced since Woodward's experiments were made, and it seems probable that this source of illumination would now be more economical and convenient than the use of the electric light in the absence of a "plant" for producing electricity for general purposes of illumination. At a meeting of the Society for Advancement of Photography, in Berlin, held March 26, 1886, Herr Miethe called attention to the use of the magnesium light in photography, and stated that its use had heretofore been very much restricted by the price of magnesium wire, but that this difficulty had now been removed, inasmuch as the factory of Schering produces this wire at a very moderate price.

Lamp-light.—Dr. R. T. Maddox, of England, one of the pioneers in photo-micrography, demonstrated some years ago that satisfactory photo-micrographs can be made with comparatively high powers by the use of lamp-light. He was kind enough to send me a drawing of his apparatus in 1883, but it has been mislaid and I have not at hand the number of the *British Journal of Photography* in which it is described. It is, however, essentially the same arrangement as that which has since been used in this country by Mr. Walmsley and others. The details are shown in Fig. 2872, which represents the apparatus as described by Walmsley.

"Any coal-oil or petroleum lamp of good illuminating power, and which can be placed at any desired height above the table, may be used. The Fiddian illuminator (originally intended for microscopic purposes) has been

found admirably adapted to use with the camera, and is the one figured in the illustration. It gives a strong white light through the lens composing its front, all the other rays being cut off by the metallic chamber and chimney containing the flame. It can be raised to any required height, and is recommended as being the best lamp for the purpose. . . . In using this apparatus, the base-board is to be placed upon a solid table and the camera firmly secured to the platform, as shown in the

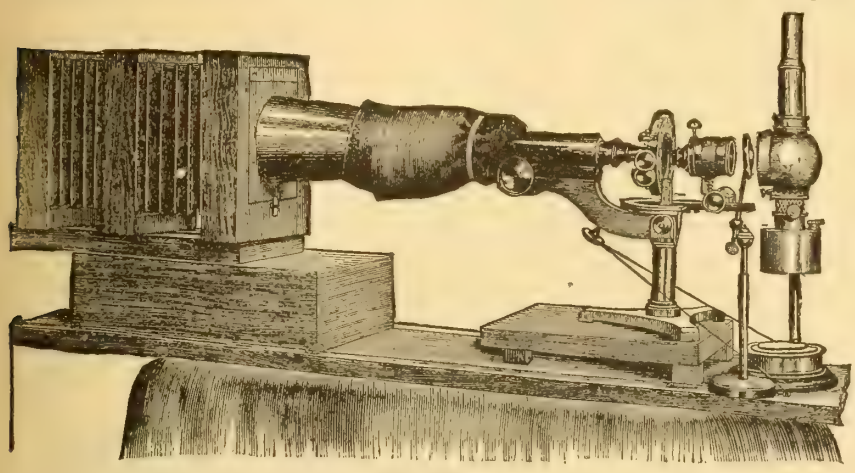

Fig. 2872.

illustration. The microscope (from which the eye-piece has been removed, and the tube, lined with a roll of dead-black paper), is to be inclined to a horizontal position and firmly secured to the board by turn-buttons, with the end of the body inserted in the cone front of the camera, about the joining of which a piece of black cloth or velvet is to be wrapped to exclude extraneous light. The lamp is now to be lighted and raised to such a height as will bring the flame exactly even with the centre of the stage, the direct light being used without the mirror, which must be removed. It is presumed that the proper object-glass has already been attached to the microscope-body, and that an achromatic condenser has likewise been inserted in the sub-stage. A Kellner eye-piece answers admirably for this purpose. A secondary condenser is sometimes necessary between the lamp and the stage, as shown in the woodcut, to secure a bright and even illumination all over the focusing screen." (*Journal of the Royal Mic. Society*, August 1883, p. 557.)

That very excellent results may be obtained by means of such an apparatus is demonstrated by many photo-micrographs in my collection, made by Dr. Maddox, of England, by Mr. Walmsley, and especially by the admirable work of Dr. J. D. Cox, of Ohio.[2]

Dr. Cox says: "The apparatus I use is very simple. It consists of Walmsley's photo-micrographic camera with cone of *papier mâché* attached, and a common coal-oil lamp, with broad, flat wick an inch and a half wide. In selecting a lamp I chose one having a strong draught and good combustion, giving an intense white flame. In using it, the edge of the flame is turned to the microscope, as in the resolution of difficult tests. To obtain the desired amplification, even with a one-fifteenth inch objective, the full extension of the camera bellows is necessary, or the use of an amplifier in the body tube. Without pretending to be sure that my method is the best, I will still say that I have thus far got the best results by using the No. 1 eye-piece in the microscope, and no other amplifier."

Mono-chromatic Light.—When the full light of the sun, reflected by the mirror of a heliostat, is brought to a focus by the sub-stage condenser, we have a concentration of the heat-rays as well, and this to such an extent that the object, or the balsam setting of the lens used in photographing, may be injured. The same is true of the electric light. For this reason it is customary to pass the light through a solution which filters out the heat-rays. Woodward used a saturated solution of ammonio-sulphate of copper for this purpose, and the writer has followed his practice with satisfactory results. The solution is made by adding sulphate of copper to strong *aqua ammoniæ*. After being filtered, this solution is enclosed in a flat glass cell, and this is interposed in the course of the light back of the sub-stage condenser. The cell should have parallel sides of plain glass, separated by a space of about half an inch. Back of this cell it is customary to place a lens of long focal distance—about eight inches—to condense the light from the mirror of the heliostat. The cell should be so placed that the cone of light emerging from it is about one-fourth to one-half an inch in diameter. This cone of light is next received by the achromatic condensing lens on the sub-stage of the microscope, which must be adjustable forward and backward in order to secure the proper illumination for objectives of various power. The best light is obtained by having a pin-hole diaphragm in front of the achromatic condenser, so that the mono-chromatic light emerges from a very small aperture. The divergent cone of light coming from this minute aperture must be carefully centred in the axis of the lens by which the image to be photographed is projected. The size of the circle of light upon the glass slip carrying the object will be regulated according to the size of the field of view taken in by the objective in use.

Instead of a condensing lens and a flat cell containing ammonio-sulphate of copper solution, we may use a glass globe containing the same solution, as proposed by Zeiss. This apparatus is shown in Fig. 2873, and is described as follows:

"A glass globe, seven inches in diameter, is held by the neck in a wooden frame consisting of a base-plate, two uprights, and a cross piece. The globe is filled with ammonio-copper solution, and placed in front of the lamp, so that mono-chromatic light can be received by the mirror or condenser. The space between the globe and the uprights is closed by a thin wood screen, which also extends five inches upward, and three-fourths of an inch on each side of the uprights, shutting off extraneous light more completely. The lamp intended to be used with the globe is a Siemens gas-burner, and should be placed about six inches behind the globe" (*Journal Royal Mic. Soc.*, June, 1886, p. 515).

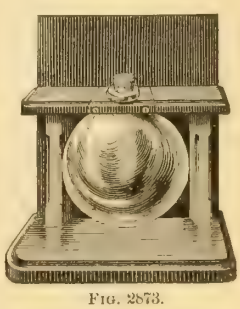

Fig. 2873.

Actinic and Visual Focus.—There is another advantage in the use of mono-chromatic light in photo-micrography. It is a well-known fact that the visual and actinic focus are not in exactly the same plane when an image is projected by means of ordinary white light. The more refrangible violet rays are brought to a focus at a point nearer to the object than are the rays from the red end of the spectrum, which have a large share in the formation of the visual image. This source of difficulty is removed by the use of mono-chromatic light, which is also less trying to the eyes than white light.

The difference between the actinic and visual focus is greater in the case of low-power lenses, unless these are specially corrected for photography, than in carefully

corrected lenses of high power. Mr. Walmsley says: "I have seen objectives of low power in which there was no apparent difference between the visual and actinic foci, and which gave without any further corrections—negatives as sharp as the image seen upon the focusing screen; but such instances are rare, and cannot be counted upon. I would, therefore, reiterate—for all powers lower than one-fourth inch employ only those specially corrected for photography" (*J. R. M. S.*, London., February, 1886, p. 146). The source of difficulty referred to applies also, although in less degree, to the image projected by objectives of high power. Dr J D Cox remarks upon this subject as follows:

"If the statement had been that a sharp picture may be taken when the object is exactly in focus with a high power, I should not take exception to it, and I incline to think that this is what has been meant. But a sharp picture may be either a positive or a negative of the visual image seen in the microscope, and in my own work so many examples have turned out to be positives when I expected them to be negatives, that I have been led to make an investigation of the subject, in which the evidence tends strongly to show that, with our best high-power lenses the image fixed upon the sensitive plate is a positive instead of being a negative, and consequently the paper prints from this are negatives and not positives. It would be very easy to overlook this difference in a large class of photo-micrographs, because in an alternation of dark and light lines, or dark and light spaces, it often matters little which of a pair is light or dark; the picture will be equally satisfactory either way. In the case of a large majority of the microscopic objects photographed, either the positive or negative image would be good enough for the purpose intended—so good that a close examination of the point I am now suggesting would hardly occur to one. This, in fact, was my own experience until, in efforts to get a good picture of the broken edge of fragments of the finer diatoms, my attention was arrested by the fact that the appearances seen by the eye were often reversed in the print from the supposed negative which I had taken. As, in dealing with minute areolæ, this often amounted to showing a projection, where I had seen an apparent depression, and *vice versa*, it became in effect a failure to photograph what I had seen, and challenged my best efforts to overcome the difficulty" (*J. R. M. S.*, London, December, 1885, p. 1071).

General Remarks upon Light.—Whatever the source of illumination, it will be necessary to keep in mind certain general principles. Of course, no light must reach the plate except that which comes through the objective by which the image to be photographed is projected. This object is attained in two ways:

(*a*) By the use of a light-proof camera-box, which is connected with the tube of the microscope by means of a cone of blackened pasteboard, or some other device.

(*b*) By working in a room from which all light is excluded except that which comes through the tube of the microscope. In this case the whole room becomes a *camera obscura*, and it is unnecessary to have a light-proof connection between the tube of the microscope and the screen upon which the image is projected.

Both of these methods of working have their special advantages. The employment of a camera-box gives us an apparatus which may be transported from place to place, which may be used in any suitable room, and which can be put aside when the room is required for other purposes. The other plan requires a room specially arranged for the purpose—that is to say, a room from which the light can be completely excluded, and having a properly located aperture through which light can be admitted to the condensing lens on the sub-stage of the microscope. When sunlight reflected by a heliostat is to be the source of illumination, it is essential that the aperture through which the light is admitted should face directly south, and the optical axis of the microscope must correspond with the meridian of the locality.

The main advantages of the dark room are that the screen may be moved forward and back for any distance allowed by the depth of the apartment; that the projected image may be seen by the operator while standing at the microscope, and may be roughly focused from that point by means of the coarse adjustment; and that the final focusing can be effected at the screen without resorting to any device for excluding extraneous light, such as the strip of black velvet commonly employed by photographers.

The writer, following the practice of Woodward, has done most of his work in a dark room, and has been well satisfied with this mode of operating. It will be found preferable for laboratories which are regularly fitted up for photo-micrography. On the other hand, those who only work occasionally, and who cannot devote a suitable room to this especial use, will find the ordinary camera-box the most satisfactory arrangement, especially if they propose to use a petroleum lamp as the source of illumination.

Reflection from the Interior of the Tube of the Microscope.—Novices in the art of photo-micrography are very commonly perplexed by the appearance of a central spot

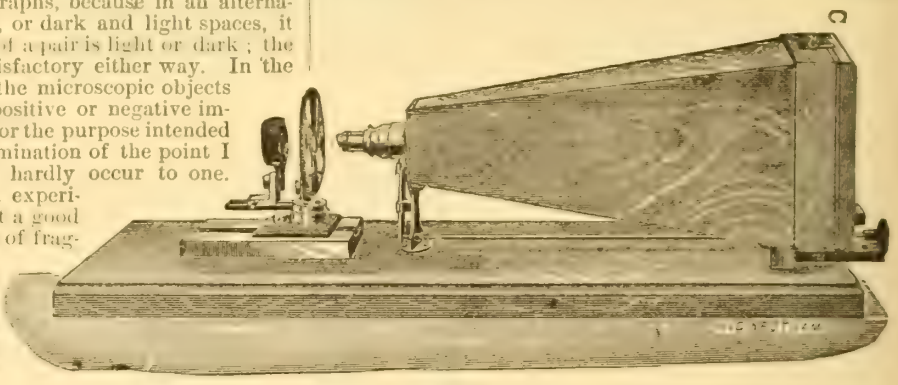

Fig. 2874.

or circle of light upon the screen, which seriously detracts from the beauty and value of the picture. This is due to reflection from the inside of the tube of the microscope. It is to be corrected by slipping into the tube a cylinder of paper of a dead-black color. The writer is in the habit of accomplishing the same end by the use of an eye-piece with the lenses removed. The blackened diaphragm which is placed between the lenses of a low eye-piece serves to exclude these reflected rays, and at the same time cuts down the field upon the screen and gives it a sharp outline, which is under most circumstances an advantage.

With reference to the manipulation of the light which passes through the sub-stage condenser, we would say that this is a matter of prime importance, and that success will depend largely upon having the light properly centred and the condenser adjusted at the most favorable point for securing good definition.

Diffraction.—The diffraction spectra which are so often seen in photographs made by transmitted light mar the beauty of the picture and are a source of confusion in interpreting the meaning of the photographic image. They are to be avoided by the use of carefully corrected objectives, by carefully centring the light, and, finally, by interposing a piece of ground glass back of the sub-stage condenser. The last-mentioned procedure is especially necessary when lamp-light or unfiltered sunlight is employed.

Apparatus.—A very simple form of apparatus will suffice for photographing with low powers. Fig. 2874 represents an apparatus devised by Mr. H. F. Atwood, and described in the *Journal of the Royal Microscopical*

Society (April, 1885). It is manufactured in this country by the Bausch & Lomb Optical Co., and is to be commended for its simplicity and convenience. It will be seen that the stage is adjustable forward and backward for a considerable distance, and that this movement answers the purpose of a coarse adjustment, and gives ample range for the employment of low powers. A greater extension of the camera-box would be a desirable feature.

The writer has found that most satisfactory pictures of thin sections of tissues, etc., may be made with an amplification of from two to ten diameters, by the use of a photographer's "view lens." This is to be brought quite near the object—eight to ten inches—and the enlarged image is projected upon a screen removed to a considerable distance behind the lens. The amplification, of course, increases with the distance of the screen, and the lens must be moved closer to the object, according as this distance is increased. The photograph of spinal cord (Fig. 5), and that of a section of a tuberculous lung (Fig. 4) in Plate XXV., accompanying this article, were made with such a lens. The superior penetrating power of a landscape lens, the large field of view which it includes, and its optical qualities generally when it is produced by a good maker, make it superior to an ordinary low-power objective for the purpose mentioned. It may be used in connection with such an apparatus as that of Mr. Atwood—with a longer camera—or in a dark room to which light is admitted through a single aperture which leads, by means of a light-proof tube, directly to the object upon the stage of the microscope. A diaphragm of the size of the field of view which is to be photographed, should be placed back of the object.

No heliostat is required, as ordinary diffused daylight, or better still, light reflected from a bright blue sky, or from white clouds, is quite sufficient. No substage condenser is used, and it will be found in practice that, as a general rule, the quality of the light will be better when our apparatus points directly toward the blue sky than when a mirror or a condensing lens is interposed. For this reason it is desirable to work in an elevated room which has an outlook directly upon the blue sky, and when we cannot obtain such an outlook in a horizontal plane we may incline all of our apparatus so that the optical axis of the microscope will point above the horizon. When this is impracticable on account of the proximity of tall buildings or of other objects which obstruct the view, we may place a plane mirror, outside the window and opposite the aperture through which light is admitted, in such a position as to reflect the light falling upon it in a perpendicular direction, at a right angle, and into the aperture.

Such an arrangement as this will be very suitable for photographing growing colonies of bacteria upon gelatine plates, and also for making an enlarged positive picture from a small negative. Higher powers may be used in the same way. In the vicinity of San Francisco, where the sky is habitually bright, and the actinic power of the light reflected from the heavens very great, I have even made a satisfactory photo-micrograph with an amplification of six hundred diameters, without the use of a heliostat, and by means of a Zeiss one-eighteenth inch homogeneous immersion objective. The time of exposure was, however, very long—about half an hour—with an Eastman "extra-rapid" dry plate.

As a general rule, it may be said that this method is not available for objectives of higher power than one-half inch, or for an amplification of more than fifty diameters. When the atmosphere is at all hazy, as when it is loaded with the smoke of a large city, the limits are considerably below this.

If sunlight is to be used with high powers, a *heliostat* of some kind will be essential. And as it is a difficult matter to regulate a heliostat so that the light reflected by its mirror will remain for several hours in one place, the use of a heliostat-regulator becomes necessary. The writer used for a number of years the regulator devised by Woodward, which is manufactured by Kübel, of Washington.

For short exposures an adjustable plane mirror may be used, such as the "New Porte-lumière" of James W. Queen & Co., of Philadelphia, which is shown in Fig. 2875. This is described as follows: "The mirror is mounted in a thin metal frame, strengthened at the back by a rib of thicker metal. It is supported upon an axis near the middle, with which it turns in the ends of two metal posts that stand out from the rotating frame of the base. The movement of rotation or orientation is given by two knobs inside the window, which turn the parts carrying the mirror smoothly and evenly in a groove in the main frame, which is fastened to the window-shutter. The movement of elevation is obtained by turning the head of an endless screw, also within the window, working a nut on the end of a lever outside" (Fig. 2875).

Direct sunlight, reflected by a plane mirror, made convergent by means of a low-power lens (8 inches focus), passed through an ammonio-sulphate of copper solution, and concentrated upon the object by means of an achromatic condenser, gives us a powerful light of the best quality, which requires a comparatively short exposure even with the highest powers. Fig. 2 of Plate XXV. is from a negative made by the writer with such a light, in Havana, in 1879. The blood-corpuscles, from the finger of a patient with yellow fever, are magnified 1,500 diameters by means of a Zeiss $\frac{1}{18}$ inch objective. This is one of many similar pictures made at the same time. The amplification might have been pushed much farther, so far as the light is concerned, if there had been anything to gain by doing so. But this would have been at the expense of clearness of definition, as I found this to be about the limit of satisfactory work with the objective named.

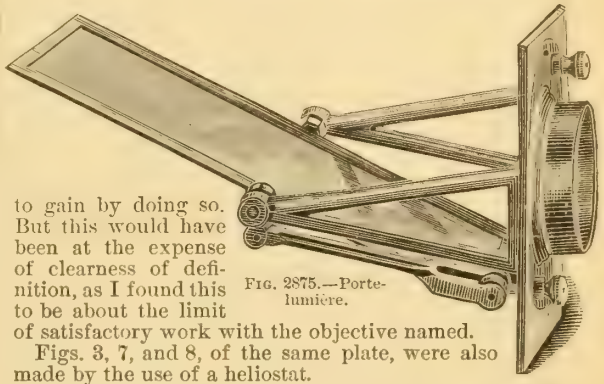

Fig. 2875.—Porte-lumière.

Figs. 3, 7, and 8, of the same plate, were also made by the use of a heliostat.

The essential features of a *stand* for photo-micrography are, that it may be inclined to a horizontal position, and that it has a sub-stage upon which to mount and focus forward and back an achromatic condensing lens. Of course it will have, in this country, the "society screw," and will thus be adapted for use with all objectives of English or American make. In addition to these essential features it will be found very convenient to have a mechanical stage, and arrangements for centring the sub-stage with its condensing lens. Following Woodward's recommendation, I obtained at the outset of my work the large stand of Powell & Lealand, and have found it to be admirably suited for the purpose. One feature of value is the fact that the body can be detached, thus giving a full field when low powers are used. Good work may, however, be done with a much cheaper instrument, and I have managed to get on very well with the army stand of Zentmeyer, even when using the highest powers. This stand has an easy-moving glass stage. In the absence of a suitable achromatic condensing lens attached to the microscope, we may use an objective. I prefer a first-class objective of high power—$\frac{1}{4}$ inch or above—but a lower power may be used by placing a pin-hole diaphragm over the front lens. The Abbé condenser and others of similar pattern are not suitable for photo-micrography. Walmsley recommends the use of a Kellner eye-piece as a condenser.

Objectives.—In the earlier days of photo-micrography we were reduced to the necessity of using objectives made for ordinary work with the microscope, and which

were corrected to do their best work with an eye-piece at a fixed distance. For lenses of low power and moderate angular aperture, the limits of the distance within which a well-defined image could be projected were not so restricted as in the case of those of higher power and wider angle. The more perfect the performance of a lens under the conditions for which it has been corrected, the more essential it is that these exact conditions shall be maintained in using it. Thus the homogeneous oil-immersion objectives of Zeiss, made according to mathematical formulæ furnished by Professor Abbé, are corrected to give the best possible definition with the eye-piece at a distance of eight inches, and any considerable variation from this distance seriously impairs their performance. When, therefore, we attempt to obtain increased amplification by removing the screen upon which the image is projected to a distance from the object, we find that there is a limit beyond which we cannot go without serious loss of definition, and that this limit varies for different objectives. In lenses provided with a cover-correction we may to a certain extent remedy the defects arising from the removal of the screen and the corresponding shortening of the focal distance of the objective; the greater the distance of the screen, the closer the objective must be brought to the object to bring it in focus.

The same thing may be accomplished, within certain limits, by the use of an adjustable *amplifier* within the tube of the microscope. In using the homogeneous immersion objectives of Zeiss, the writer has obtained excellent results with a Tolles' amplifier, obtained in 1879 upon the recommendation of Woodward. During the same year, Woodward recorded the results of his experience in the use of an amplifier, in the *Journal of the Royal Microscopical Society*. Having been disappointed in the use of concave lenses which Zeiss had sent him to be used in connection with his immersion lenses in photography, he made experiments with an amplifier which had been manufactured for him by Tolles, of Boston, a number of years before. He says: "Long before I had received them" (the concave lenses furnished by Zeiss) "I had theoretically devised a method of making these projections, which on trial fully answered my expectations, and gave, at any distance I chose to select, images equal in flatness, definition, and brilliancy to the best I could obtain with the ten-inch tube. This method consists in placing a suitable achromatic negative lens at the end of the draw-tube of the microscope body, and slipping it by trial to the proper position to bring the image to a sharp focus on the screen at the distance selected, while the objective remains in precisely the same focal position that was found to give the best image with the ten-inch tube. The course of the rays through the objective, under these circumstances, remains the same whether the image is projected one or four metres, or any intermediate distance, and provided the concave has the requisite qualities, the sharpness of the image is unimpaired" (*op. cit.*, p. 664). The amplifier used was "a negative achromatic meniscus of about 6.5 inches virtual focus, and 2.7 of an inch in diameter." Woodward says further: "It will be readily understood that the best position of the amplifier with the Zeiss one-eighth or one-twelfth, for the projection of the image to say ten feet distance from the object, will also be the best position for all other objectives, provided their corrections are best neutralized when they are focused on the object with the ten inch tube; and therefore the positions of the draw-tube corresponding to the best images at a series of selected distances, having been found by careful experiment with any selected objective, may be used successfully with any other objective corrected for the ten-inch tube. Indeed, this method may be advantageously resorted to in the case of objectives provided with a screw-collar in place of the usual method, in which the screw-collar is used to correct the aberrations introduced by distance. The positions of the amplifier, as indicated by the scale on the draw tube, having been found for the distances at which the pictures are to be taken, it is only necessary, in subsequent work with the same amplifier, to set it, by means of the draw-tube, at the position known to be best for the distance selected, and then to focus with the fine adjustment in the usual way."

There has been much difference of opinion as to whether it is best to obtain the desired amplification by the use of the objective alone, or of this in combination with an adjustable amplifier, or whether equally good results can be obtained by leaving the eye-piece in position, and bringing the screen close to it. The experience of Woodward was opposed to the use of an eye-piece and my own experience corresponds with his. But I have not had the opportunity to work with eye-pieces constructed especially for photography, and do not doubt that the defects which have prevented me from obtaining satisfactory results with the eye-pieces in my collection could be overcome by the opticians. One principal trouble I have found to be the curvature of the field, which makes it impossible to bring into focus the centre and the margins of the field of view at the same time. But there can be no doubt that eye-pieces specially constructed for the work can be used with advantage. Only those of comparatively low power will, however, be found useful. Professor Abbé has given the following opinion with reference to eye-piece amplification, in general:

"The essential principle for a valid comparison of the telescope and the microscope, is that every microscope involves in its action that of a given telescope. The effect of the microscope cannot, in any case, extend further than the effectiveness of such telescope. Now, the most trustworthy power of eye-piece for a telescope is approximately forty per inch of the diameter of the objective, *i.e.*, one-fourth inch focal length for every telescope in which the proportion of focal length to aperture is 1 to 10. This relation of eye-piece to objective in the telescope is exactly paralleled in the microscope, when to a one-eighth inch dry objective of maximum aperture is applied (with a ten-inch tube) a one-inch eye-piece, or a three fourths inch eye-piece with a homogeneous immersion one-eighth inch of 1.33 N. H" (*J. R. M. S.*, 1884, p. 804).

There is reason to hope that the optical difficulties with which the pioneers in the art of photo-micrography have had to contend, have been to a considerable extent over come by the recent improvements made in Germany in the manufacture of glass for optical purposes, and by the "apochromatic objectives" and "projection eye-pieces" made of this glass by Carl Zeiss, of Jena. The writer has not yet had an opportunity to test the performance of these objectives and eye-pieces, but anticipates that they will be found to constitute a very decided improvement in the art of photo-micrography.

The following account of the advantages claimed for the new objectives is given in a recent number of the *Journal of the Royal Mic. Society*:

"New kinds of glass and a greatly improved method of correction have been employed, with the result that the secondary spectrum is removed, and the spherical aberration uniformly corrected for the different parts of the spectrum. There is, therefore, a much more perfect concentration of the rays in the image than with the best objectives hitherto made, and there is neither focal difference nor spherical aberration even in the case of the chemically effective rays."

With reference to the projection eye-pieces, the statement is made that "they consist of a convex lens and a compound system which, like the apochromatic objectives, is most carefully corrected both spherically and chromatically, and is entirely free from secondary chromatic aberration and from difference of focus between the visual and chemical rays."

Focusing the Image.—As the screen is commonly removed to such a distance that the operator cannot reach the focal adjustment screws of the microscope, it is necessary to have some device for focusing. Woodward used a jointed rod, and a pulley which was connected with the fine adjustment-screw by means of a cord. This is seen in Fig. 2871 and is described by Woodward as follows: "On the table which supports the microscope (*e*) two brass shoulders, each two inches high, are screwed. Through these runs an iron rod nine inches

long, on which slips a brass pulley (*d*) which can be clamped at any point. It is evident that whenever this iron rod is turned the pulley turning with it will move the fine adjustment of the microscope. To effect this, the iron rod terminates in a square extremity, so that a joint of an ordinary fishing-rod, to which a brass ferule, shaped like a watch key, has been riveted, enables the operator to focus the microscope at any ordinary distance. The rod, being graduated into feet and inches, enables the operator to record the distance employed for each picture. When the focusing is completed, the rod is removed. I have found this simple and cheap arrangement superior in delicacy and convenience to any of the more costly arrangements I have heretofore tried." There can be no doubt as to the delicacy of this arrangement in skilful hands, as Woodward used it in making his famous pictures of *Amphipleura Pellucida*. The writer has, however, found an arrangement, which he has used during the past six years, to be more convenient. A cord to which a suitable weight is attached is carried around the grooved head of the fine adjustment-screw, or around a pulley connected with it, as in Woodward's device. This cord passes, first perpendicularly upward to a small pulley fixed at a point above the microscope, then horizontally to a pulley attached to an upright support secured to the table *f* (Fig. 2871), then perpendicularly downward to a spool attached to the same support, in a convenient position to be reached by the hand of the operator when standing at the screen in a position for focusing. The cord should be a strong waxed linen thread which will not stretch. It is wound around the spool, and in changing the position of the table *f*, is wound up or unwound as required. The spool itself is adjusted to turn smoothly, but with sufficient friction to prevent the weight at the opposite end from moving it. The proper degree of friction is secured by means of a coiled spring placed upon the axis around which the spool revolves, which is compressed between it and the frame. This arrangement gives the operator perfect control of the fine adjustment while standing at the screen, no matter how distant this may be. The horizontal portion of the cord is at such a height that the operator can walk beneath it without disturbing it.

I am in the habit of working with my microscope and screen at such a height that the optical axis of the instrument is exactly on a level with my eye when standing erect. This position I have found to be less fatiguing than one which requires the operator to stoop or to sit, as Woodward was in the habit of doing.

In working in a dark room the image is first roughly focused upon the screen with the coarse adjustment, while the operator is standing at the microscope. Then the operator goes to the screen, and by means of the spool and cord, focuses as accurately as possible upon the ground-glass plate, which, of course, must be in the exact position which will be occupied by the sensitive plate when the exposure is made. It will be found, when there are any fine details to be brought out, that it is impossible to obtain a satisfactory focus upon ground glass. Indeed, it will be impossible to see them. The final focusing, therefore, in all work with high powers, is done upon a sheet of plain glass by means of a focusing lens. A low eye-piece may be made to answer the purpose of a focusing lens. A convenient arrangement is to have the plain glass permanently placed in the position to be occupied by the sensitive plate, and to have a frame containing ground glass which can be placed in apposition with this and removed at pleasure. For remarks on actinic and visual focus see page 653.

In making photographs by transmitted light, we have to consider, not only how we can bring the object accurately into focus, but what is the best focal adjustment to give a true picture of the object in question.

In making photo-micrographs of blood-corpuscles, for example, we may so focus as to have the thicker margin of the corpuscle represented, in a positive print, by a white ring, as in Fig. 2, Plate XXV., or by a slight change in the adjustment, we may have a dark marginal ring. Again, in highly refractive bodies, we may have a variety of appearances due to slight differences in focal adjustment, and we cannot say that any one of these appearances is a true picture of the object in question. This is well shown in Fig. 2876, which represents air-bubbles in water (1); air-bubbles in Canada balsam (2); and fat-globules in water (3). The figure is from Professor Ranvier's work on Histology ("Traité technique d'Histologie," 1878). In each of the figures A represents the appearance when the objective is focused to the bottom of the bubble; B, the appearance when the middle plane of the bubble is brought into focus; and C, that presented when the top of the bubble is brought into focus. This figure shows us that bodies which have a greater refractive power than the surrounding medium have a white centre surrounded by a black ring, and that upon withdrawing the objective the centre becomes smaller and the ring larger. On the other hand, when the refracting power is less than that of the surrounding medium, the marginal ring becomes broader and the white centre smaller when the objective is lowered.

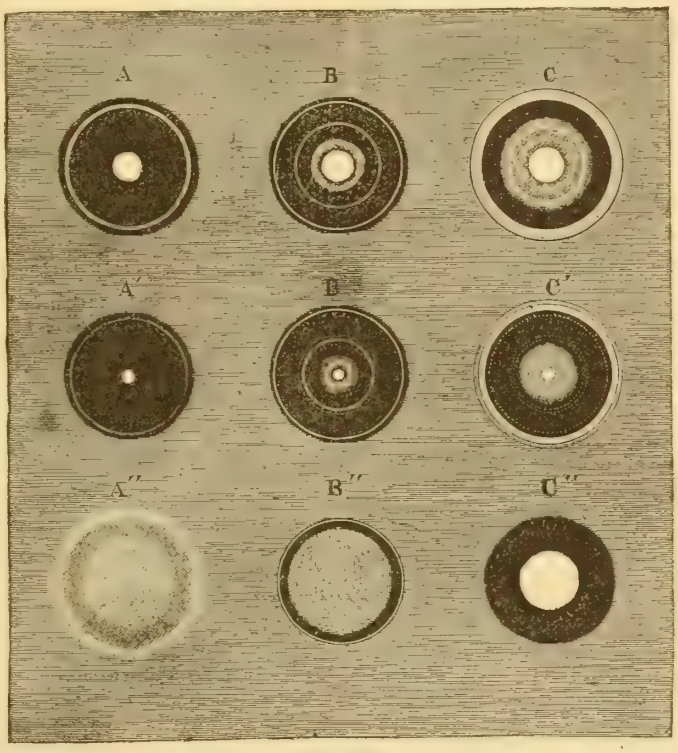

Fig. 2876.

Exposure.—No specific directions can be given as to the time of exposure, as this depends upon so many different elements—actinic power of the light, nature and color of object, objective employed, distance of screen, sensitiveness of plate, etc. The beginner will necessarily have to make many experiments before he can judge correctly of the time of exposure required under various circumstances, and even the expert commonly finds it necessary to make two or three exposures in order to determine the best time for a particular object and optical combination. The exposure is readily made by interposing a piece of

pasteboard in front of the tube of the microscope, or back of the achromatic condenser, the slide is then drawn from the plate-holder, and, returning to the microscope, the operator withdraws with a quick movement the pasteboard which shuts off the light, and as quickly returns it at the end of the time fixed upon. With very sensitive plates and a strong light a drop-shutter may be found necessary. But, as a rule, it will be better not to work with the most sensitive plates, as it is more difficult to time them properly, and as they do not keep as well as those which are not so sensitive.

Dry and Wet Plates.—The very great convenience of having a plate always ready for use has caused the dry plates to supplant wet plates to a large extent in photography. In a recent article in Professor Vogel's *Photographische Mittheilungen*, the statement is made that in England wet plates have almost disappeared from use, and are scarcely known to many of the younger photographers. This is regretted by the author of the article in question, on account of the superior results which may be obtained by the use of wet plates. I believe it to be true also in photo-micrography, that better results may often be obtained with wet plates. But it is such an advantage to get rid of the silver bath and to have a plate always at hand ready for an exposure, that it is doubtful whether wet plates will ever again find much favor.

As most makers give formulæ for the *development* of their plates, and as this belongs strictly to the technique of photography, no details will be given here with reference to this and other processes relating to the preparation of the negatives.

Positives on glass for projection on a screen, are very quickly made by the use of a camera, or by simple contact with the negative and exposure to light. The latter method gives very good results and commends itself by reason of its simplicity. The negative is placed in a plate-holder with the film at the back. A dry plate of the same size is placed over this so that the two films are in contact. The plate-holder is then closed and the exposure made by holding it up before a gas-jet or a petroleum lamp, or before the door of the dark room opened on a crack so as to admit a little diffused daylight, and drawing the shutter. The time of exposure will be very short, one to ten seconds, according to the intensity of the light and the distance from it at which the exposure is made.

Measurement of Amplification.—It is desirable that the exact amplification should be known and stated for every photo-micrograph which is supposed to have some scientific value, and especially for those which are used to illustrate scientific papers. The amplification for any given optical combination is easily ascertained by projecting upon the screen the lines upon an accurately ruled stage-micrometer, and measuring their distance from each other in the projected image, by means of dividers and a graduated scale. If, for example, the lines upon the stage-micrometer are $\frac{1}{1000}$ of an inch apart, and upon the screen they are found to be half an inch apart, it is evident that the amplification is exactly five hundred diameters. It is always best to make the magnifying power correspond to some even number, by moving the screen forward or backward, otherwise it will be found inconvenient to make comparisons as to size when the same object has been photographed at different times or by different persons.

In practice it will be found a very great convenience to fix the amplifying power of each objective to be used at the outset, for various positions of the screen.

The writer is in the habit of drawing a line, in a plane parallel with the optical axis of the microscope, on the floor of the dark room, and of recording upon it the amplification for various objectives, in different positions of the screen. Thus:

1 in.	$\frac{1}{6}$ in.	$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.
100	600	1000	250	500

General Remarks.—Having the necessary apparatus for work, success in photo-micrography will depend upon technical skill and experience, (*a*) in the selection and preparation of objects for photographing; (*b*) in the adjustment of the light and optical apparatus for projecting a well-defined image; (*c*) in the skill of the operator as a photographer. In other words, unless a portion of the work is delegated to someone else, the photo-micrograph represents the work of a skilled preparator, of an accomplished microscopist, and of an expert photographer. This being the case, it is to be expected that those who assume that they only require a microscope, a camera, and a box of dry plates in order to make photo-micrographs of the various objects in their collection, will meet with disappointment. The technical difficulties are very considerable, and are only to be mastered by careful attention to details and great perseverance. The young physician who thinks he might find pleasant occupation in making photo-micrographs while waiting for patients, will find that a considerable expenditure of time and money will be required in order to attain any very satisfactory results. We advise him rather to practise with his pencil, and to draw in his note-book the objects of interest he sees under the microscope.

But the pathologist or bacteriologist engaged in original researches, will find it well worth his while to master the technical difficulties and to make a photographic record of his observations, both for his own satisfaction and because such a record is beyond dispute, and may serve to establish priority of discovery, or to convince those at a distance, who are engaged in similar pursuits, of the reliability of the observations recorded. Finally, we would say that every well-equipped pathological laboratory should be provided with the necessary rooms and apparatus for photo-micrography.

Description of Plate XXV.

Fig. 1. Blood from finger of yellow fever patient in Military Hospital, Havana (1879). Spread upon cover-glass; mounted dry; photographed with Beck's one-fifth inch objective (dry); sunlight with heliostat and Powell & Lealand's condenser; wet plate, iron developer, negative intensified; magnified four hundred diameters.

Fig. 2.—Blood from finger of yellow fever patient in Military Hospital, Havana (1879). Spread on cover-glass; mounted dry; photographed with Zeiss's one-eighteenth inch homogeneous oil-immersion objective, and Tolles' amplifier; sunlight with heliostat and Powell & Lealand's condenser; wet plate, iron developer, negative intensified; magnified one thousand four hundred and fifty diameters.

Fig. 3.—Tuberculosis of lung; section stained with Bismarck brown and mounted in Canada balsam; shows a conglomerate tubercle on the left, a miliary tubercle containing giant-cell on the right, and pulmonary alveoli filled with epithelioid cells or amorphous granular material; made with a Collins one-inch objective; sunlight and heliostat; Eastman's dry-plate and ferrous-oxalate developer; magnified fifty diameters.

Fig. 4.—Miliary tuberculosis of the lung; section stained with Bismarck brown and mounted in Canada balsam; made with a photographer's view lens; diffused daylight admitted through a small aperture to dark room; Eastman's dry-plate and ferrous-oxalate developer; magnified about seven diameters (Baltimore, 1884).

Fig. 5. Dorsal cord of man, low down; mounted in glycerine, stained only by the Müller fluid in which cord had been preserved; made with a photographer's view lens; diffused daylight admitted to dark room through small aperture; Eastman's dry-plate, ferrous-oxalate developer; magnified about six diameters (Baltimore, 1884).

Fig. 6.—Anthrax bacillus from spleen of rabbit killed by experimental inoculation; splenic pulp spread upon cover-glass, stained with Bismarck brown and mounted in Canada balsam; made with Zeiss's one sixth inch objective (D D. dry); sunlight with heliostat and Powell & Lealand's condenser; Eastman's dry-plate and ferrous-oxalate developer; magnified about two hundred and fifty diameters (Baltimore, 1884).

Fig. 7.—Giant-celled sarcoma; section stained with Bismarck brown and mounted in Canada balsam; made with Powell & Lealand's one-inch objective; sunlight with heliostat and Powell & Lealand's condenser; Eastman's dry-plate and ferrous-oxalate developer; magnified seventy-five diameters (Baltimore, 1884).

Fig. 8.—Bacilli and spirilla from gutter-water; dried upon cover-glass, stained in Bismarck brown, mounted in water; made with Zeiss's one-eighteenth inch homogeneous oil-immersion objective; sunlight, heliostat, Powell & Lealand's condenser; wet plate, iron developer; magnified five hundred diameters (Baltimore, 1881).

George M. Sternberg.

[1] Report to the Surgeon General of the United States Army, on the Magnesium and Electric Lights as applied to Photo-micrography. By Brevet Lieutenant-Colonel J. J. Woodward, Assistant Surgeon, U. S. Army. Washington, January 5, 1870.

[2] On Some Photographs of Broken Diatom Valves, taken by Lamplight. By Jacob D. Cox, LL.D., F.R.M.S. Journal R. M. S., London, December, 1884, p. 853.

PHRENIC NERVE (*ἡ φρήν*, the diaphragm or midriff). The phrenic nerve is the continuation of the fourth cervical nerve, with an accessory cord from either the third

or fifth cervical joining it. Deeply in the spinal cord the nerve may be traced toward the respiratory portion of the medulla oblongata. The phrenic nerve descends from its origin in the neck, crossing very obliquely the superficial surface of the scalenus anticus muscle down to the attachment to the first rib, where it crosses the subclavian artery in the first part, lying between it and the companion vein. Thence both nerves take a course downward through the thorax, lying between the pericardium and the pleura, so as to reach the upper convex surface of the diaphragm, where each nerve divides into several smaller branches which perforate the muscle, and end in their distribution on its under surface—an arrangement supposed by Hilton to have been effected with the object of protecting them from the pressure of the thoracic viscera during respiration.

The right phrenic nerve is shorter, more deeply situated in the thorax, and more vertical in its course than the left, passing to the right side of the right innominate vein and of the superior vena cava.

The left nerve crosses the arch of the aorta, forming one of its anterior relations, lying between it and the left lung.

In addition to the branches supplying the diaphragm, the phrenic nerve gives on each side a distinct branch to the anterior portion of the pericardium, and throughout its course a series of very small twigs to the pleura. Both of these offsets are thought to be sensory, and Hilton makes use of this distribution to extend the application of his well-known law of nerve-supply,* regarding the serous sacs as joints. The pericardium and the diaphragm he looks upon as one structure, the diaphragm representing the muscle and the pericardium the capsular ligament.

Communicating branches are received: 1, From the superior cervical ganglion of the sympathetic, which sends a nerve to the third and fourth cervical nerves; 2, from the union of the communicans and descendens noni an offset to the phrenic is occasionally sent; 3, from that branch of the fifth and sixth cervical nerves which supplies the subclavius; 4, the right nerve at its termination sends a branch to join with those nerves going to the diaphragm, which come from the diaphragmatic plexus of the sympathetic. This plexus also distributes nerves to the supra-renal capsule, the hepatic plexus, and the inferior vena cava; 5, the left phrenic communicates with the sympathetic near the œsophageal and aortic opening in the diaphragm.

Function of the Phrenic Nerve.—The diaphragm receives its motor-supply entirely from this nerve, paralysis resulting from bilateral section. It is more than probable that sensory fibres are given to the pericardium and pleura, as well as to the upper part of the peritoneum (Henle). Luschka has shown that in rabbits some of its motor-fibres pass to the intestines.

Morbid Conditions of the Phrenic Nerve.—*Paralysis.*—Paralysis of the phrenic nerve may be said to depend upon one or other of five causes: 1, It may be part of an acute or chronic spinal myo-atrophy; 2, lead-poisoning (Duchenne, de Boulogne); 3, exposure to cold, causing a rheumatic affection of the nerve-trunk; 4, injury or compression by tumor; 5, hysteria.

Symptoms: According to the cause, the lesion may occur upon one or both sides. In pressure cases, the influence of but one nerve is impaired, while in central cases the effects are evident on both sides. When the patient inspires there is an indrawing of the epigastrium instead of a normal protrusion. The slightest exertion causes dyspnœa, though when at rest the patient may be able to breathe with normal comfort. The expulsive action of the abdominal muscles is interfered with, resulting in delay and difficulty in defecation. In a case reported by Dr. Wilks, the abdomen sank in during each inspiration, and the lower part of the chest dilated in a very remarkable manner. The lungs became congested and gradually indurated, and in a few weeks the patient died. Moreover, in such cases spasmodic action of the diaphragm is impaired, as may be demonstrated by directing the patient to sneeze or cough. Direct stimulation of the nerve is no longer followed by contraction.

There is no direct danger to life, but, while the diaphragm remains paralyzed, catarrhal affections of the lungs may bring about fatal results.

The prognosis depends upon the nature of the cause, being favorable when the condition depends on exposure to cold or hysteria, less so when it is the result of lead-poisoning, and very unfavorable when central causes have been at work.

The treatment is mainly electrical, and consists of systematic faradization of the phrenic nerve, the rheophores being applied, one on the neck just above the scaleni, and one near the diaphragm, a strong current being used. In those cases which are caused by cold, counter-irritation by leeches and sinapisms is of service.

Phrenic Neuralgia.—Peter and Falot have, independently of each other, described a form of neuralgia characterized by the occurrence of acute pain at the lower and anterior part of the thorax, along the line of attachment of the diaphragm; also by pain in a line corresponding to the course of the phrenic through the chest, as well as at the point where the nerve arises from the cervical plexus and descends over the scalenus anticus. The pain also radiates to other branches of the cervical plexus, and is felt in the neck, shoulder, over the lower jaw, and down the inner side of the arm. Painful points are felt over: 1, The spinous processes of the upper cervical vertebræ, especially from the second to the fifth, and less frequently to the sixth; 2, the phrenic nerve itself, as it pursues its course along the supra-clavicular fossa; 3, the line of attachment of the diaphragm, especially anteriorly between the seventh and tenth ribs, and more rarely posteriorly; and lastly, 4, at a point over the cartilage of the third rib.

The pain is described as being more or less continuous, but presenting exacerbations. Respiration is impeded. Muscular tremors and debility are not uncommonly present in the arm. Phrenic neuralgia is often a concomitant of other diseases, among which Peter enumerates angina pectoris (most commonly), cardiac and vascular lesions, Graves' disease, splenic and hepatic disease. The left side is mainly attacked.

For a complete account of this disease the reader is referred to Erb's treatise (from which the foregoing description has been taken) on Nervous Diseases, in Ziemssen's Cyclopædia, as well as to Peter's original article in the *Archives Générales de Médecine*, 6me série, tome xvii., 1871, p. 303.

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R. L. MacDonnell.

PHTHISIS, GASEOUS ENEMATA IN THE TREATMENT OF. This method of treatment, originated by Dr. L. Bergeon, formerly professor in the Medical School of Lyons, France, consists in the introduction into the rectum of carbon dioxide mixed with hydrogen sulphide (known more generally as carbonic acid and sulphuretted hydrogen). The apparatus required for this purpose is simple and inexpensive. James W. Queen & Co., of Philadelphia, among others, sell an apparatus for $10 which is thus described by Dr. J. Solis-Cohen:

"The apparatus for generating the carbon dioxide (Fig. 2877) consists of a square bottle in which three tablespoonfuls of sodium bicarbonate are placed. The bottle is hermetically closed by a rubber cork with two apertures, through one of which a glass tube extends to the bottom of the bottle, the upper portion (C) being expanded into a funnel and reservoir for the dilute sulphuric acid, beneath which is a glass stopcock (B) to regulate the descent of the liquid. The second aperture

* "The same trunks of nerves whose branches supply the groups of muscles moving a joint furnish also a distribution of nerves to the skin over the insertions; and the interior of the joint receives its nerves from the same source."

in the cork is filled with a curved glass tube (E) for the escape of the gas, and this exit tube is prolonged by a section of rubber tubing (F) for attachment to a rubber bag (I) of six litres capacity, in which the carbonic acid gas is to be collected. The mouth of this bag is furnished with a stopcock (H). The sodium bicarbonate being placed in the bottle, the cork is inserted, and the stopcock of the sulphuric acid reservoir is closed. This reservoir is then filled with the dilute sulphuric acid, say four ounces, and the stopcock is turned so as to allow the acid to drip on the soda. The carbonic acid gas is evolved immediately, the activity of the disengagement being controlled by the stopcock. A little gas is allowed to escape into the atmosphere, so as to drive off the atmospheric air in the bottle. Meanwhile the reservoir is rolled tightly so as to drive out all the air it contains, as far as possible, and is then attached to the exit-tube for the gas and allowed to become filled with

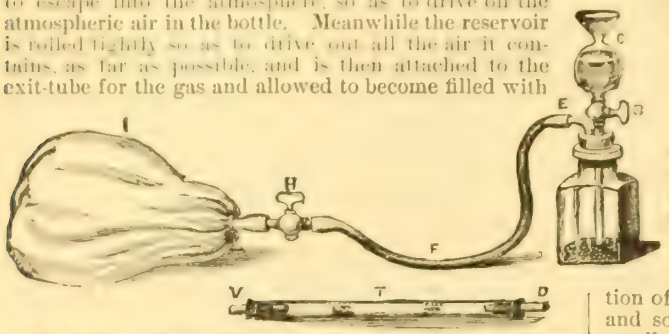

Fig. 2877.—Carbon Dioxide Generator and Reservoir. Glass tube, containing volatile medicament between two tampons of cotton. T. Medicament. V D. Connections.

the carbonic acid. It is then removed and its stopcock is closed. It must be removed before the stopcock is turned, in order that pent-up gas in the bottle shall not break the apparatus. This is one of the points to which the physician must direct the attention of his nurse before entrusting the patient to the attendant. Another point upon which stress must be distinctly laid, is the rolling of the bag to prevent retention of atmospheric air.

"The gas is now ready for use. The reservoir (I) is attached to a hand ball aspirator (J) with check valves at each end (Fig. 2878). This is attached to a metallic T-tube (D) passing through a cork which is intended to be placed in the neck of a bottle containing the medicated solution, preferably a highly charged natural sulphur water. The vertical portion of the tube is furnished with a double valve (P) to prevent aspiration of the liquid through which the carbonic acid gas bubbles, and contains an orifice at the top for the escape of the gas into the distal horizontal branch, to which is attached a

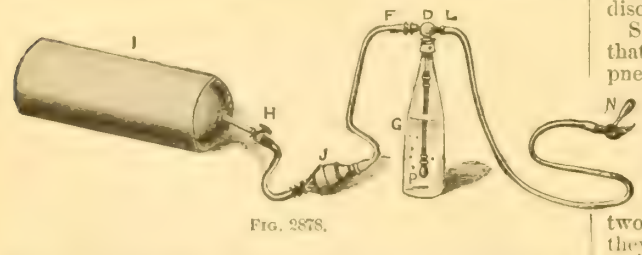

Fig. 2878.

tube (L) connected with a nozzle (N) for introduction into the rectum. This T-branch is placed in a bottle three-fourths filled with the sulphurous water—in this instance the Red Sulphur Spring water, of Virginia—and the aspirator is worked two or three times to drive out the atmospheric air in the bottle, another point to which the physician must emphatically direct the attention of his nurse. The nozzle is then inserted into the rectum of the recumbent patient and the injection made slowly. All clothing must be loose. Fifteen to twenty minutes are consumed in the process of driving the six litres of carbon dioxide through the sulphur water."

Within five minutes or less the sulphuretted hydrogen can be perceived in the breath. Three or four hours after a meal, or just before one, is the best time for the injection and it should be given twice a day. At the first injections but half the contents of the reservoir of carbonic acid should be used, so that the parts and the system may become gradually accustomed to the process.

"Should it be desired to administer some volatile medicament, as iodoform, carbon sulphide, eucalyptol, or the like, the bottle of mineral water is replaced by a bottle of common or distilled water, and between the T-tube and the injection pipe a glass tube is inserted, in which the volatile substance has been introduced between two tampons of cotton" (Fig. 2877, V T D).

Where it is not convenient to use natural mineral waters, the following formula has been found to be the best for the production of the sulphuretted hydrogen, viz.:

Sulphide of Sodium.....	gr. v.
Chloride of Sodium.....	gr. v.
Water.....	℥ xxij.

Many instrument-makers, in all parts of the country, are furnishing apparatus for giving gaseous enemata. The essential point is that such apparatus shall conform to the principles laid down above.

Therapeutic Effects.—All observers agree that the early effects of the use of gaseous enemata are diminution in cough and expectoration, cessation of night-sweats, usually a lowering of temperature, and sometimes a gain in weight. Dr. Bergeon and his pupils in France, claim a certain number of cures in cases of well-pronounced phthisis.

In this country the method is too new to permit of judgment being passed upon it yet. *E. W. S.*

PHTHISIS PULMONALIS (*Consumption, Tubercular Phthisis*). The questions of the etiology and pathology of pulmonary phthisis have been among the most vexed and disputed in medical science. For a long time the doctrine of Laënnec was accepted, viz., that all phthisis was tubercular, the result of a new-growth in the lungs, and of the subsequent degeneration of that growth and of the surrounding lung-tissue. Then Virchow and his followers proved that cheesy masses follow pneumonic processes, having no tubercular neoplasm as their starting-point, and that much which had been called tubercle by the older writers was not such. The "giant-cell" was discovered and accepted as the criterion of tubercle. It was taught that almost all phthisis originated in non-tubercular inflammatory processes in the lungs, particularly in catarrhal pneumonia. Lastly, Koch entered the arena with his tubercle-bacillus, and it now remains to reconcile the indisputable facts of this discovery with our clinical experience.

Some of our best clinicians still hold to the opinion that the larger proportion of cases of phthisis are purely pneumonic in origin, and non-tubercular from first to last. Dr. R. Douglas Powell, of London ("On Diseases of the Lungs and Pleuræ, including Consumption," Wood's Library, November, 1886), thus guardedly expresses himself: "The difference, histologically, between tubercle and catarrhal pneumonia is, however, enormous, and it is to me inconceivable how the two can be jumbled together as one product, even though they are often found in close association under apparently similar etiological conditions." . . . "It cannot, then, be said that the position of the tubercle-bacillus, with regard to the etiology of phthisis, is as yet established." . . . "We cannot say with phthisis, as with the more definite zymotic diseases, that we have health on the one hand and a specific organism on the other; that when we observe a man sickening with phthisis, the tubercle parasite is already in possession of him; and that we might hope, by exterminating the bacillus, to eliminate phthisis from our list of diseases. The characteristic lesions of phthisis are brought about by many causes, and furnish a soil upon which the tubercle-bacillus will readily grow. Epiphytic in nature, concomitant in time, neither the seed nor the fruit of the disease, it must nevertheless be allowed that the tubercle-bacillus

takes an important part in the extension and conveyance of tubercular lesions."

Other observers, also of large clinical experience, such as Prof. Germain Sée, of Paris ("De la Phthisie Bacillaire," Paris, 1884), and Dr. Adolf Strümpell, of Leipzic ("A Text-book of Medicine," New York, D. Appleton & Co., 1887), give their unequivocal support to the bacillar theory of phthisis, according to Koch. The following quotations from Strümpell's work, above named, represent the views of this class of writers: "The definition of tuberculosis no longer rests on any external anatomical character. Every disease is tubercular which is excited by the pathogenetic action of a specific kind of bacteria, the tubercle-bacilli discovered by Koch. . . . We know with certainty that they are always present in all the different forms of pulmonary tuberculosis, both in the lung itself and in the expectoration, and also in tubercular disease of other organs. . . . Koch, by his pure cultures and inoculations with the cultivated bacilli, has established the fact that these bodies are to be regarded as organized, and as the special cause of tuberculosis. . . . The entire local action of the tubercle-bacilli—that is, the pathological anatomy of tuberculosis—is almost wholly dependent on the organ examined. Tuberculosis belongs to the so-called group of 'infectious tumors,' that is, the local action of the tubercle-bacilli consists mainly in the production of a proliferation and accumulation of cells at their place of settlement, which is termed a tubercular infiltration or a tubercular new-growth. . . . Beside the spots of specific tubercular disease we very often find in phthisical lungs simple inflammatory processes, bronchitis, lobular catarrhal pneumonia, and sometimes even croupous pneumonia. This, of course, is rarely extensive. These changes may be partly due to the peculiarities of the tubercle-bacilli themselves, in exciting inflammation; but it is, of course, easily conceivable that many other excitants of inflammation may readily settle in the secretions of the bronchi and the cavities, and lead to complicating diseases of the bronchial mucous membrane and the alveoli." In weighing the language of Strümpell it must be remembered that, when he speaks of pulmonary tuberculosis, he means phthisis in its widest sense, inasmuch as he does not treat of phthisis under any other name than that of Tuberculosis of the Lungs.

Such, then, is the language of two of the most able recent writers on this subject, both of them practical men and thoroughly conversant with the questions under discussion. Many of the teachers of our own land, so far as I can learn, are still quite cautious about committing themselves to the new doctrine of the bacillar origin of phthisis. But I believe medical public sentiment is steadily drifting that way, and that soon no one will teach anything else. Twenty years ago Niemeyer, the champion of "Catarrhal Phthisis," said: "The great danger to the phthisical patient is that he may become tubercular!" To-day we reiterate this statement in substance, with a somewhat more correct idea of what it means, and would say: *The great danger to a patient with areas of consolidation in his lungs, of whatever origin, is that they may become invaded, if they are not so already, by the tubercle-bacillus.*

In adopting this view we by no means reject the teachings of clinical experience and of the post-mortem table, to the effect that many cases of phthisis evidently follow catarrhal, or sometimes croupous, pneumonic processes, giving no evidence, post mortem, of the presence of tubercular nodules. Nor do we ignore the third variety of phthisis with which we have been familiar, viz., the fibroid. But we take the following position:

1. The tubercular nodule is no longer the criterion of tuberculosis, but this criterion is always and only the tubercle-bacillus.

2. The areas of consolidation following bronchitis, lobular catarrhal pneumonia, or sometimes croupous pneumonia, are liable to be invaded by the tubercle-bacillus, and then phthisis is developed.

3. Tubercular nodules, probably developed under the influence of the bacilli of this name, are often the primary lesion of phthisis.

4. Fibroid phthisis is always an evidence of an attempt at repair. When it fails longer to limit the disease, tubercle-bacilli are found in abundance in the necrotic tissues.

While fuller details on the subject will be given in a later part of this HANDBOOK (see article, Tubercle), it may be well, before going further, to state the main facts with regard to the life of the tubercle-bacillus upon which all authorities substantially agree. The statement is taken from the work of Dr. R. Douglass Powell, above cited.

1. The tubercle-bacillus is a minute rod-shaped fungus, measuring from 0.003 to 0.0035 millimetre in length, and about one-third that measurement in thickness. The rods are straight or slightly curved, with rounded ends, and often inclose bright, spherical, spore-like granules of uniform size, arranged in linear series and separated from one another by hyaline intervals. After having been stained with methyl blue, fuchsin, or magenta, and then washed in nitric acid (ten per cent.), they retain the original dye and are thus distinguished from any putrefactive or other bacilli.

2. This organism is only capable of growth and multiplication under culture in blood-serum or animal broth, at a constant temperature of 30° centigrade. It is of comparatively (to other bacteria) slow growth, and is unable to continue its development in decomposing fluids in the presence of more rapidly growing putrefactive bacteria.

3. All the conditions essential for the development of the bacillus are, so far as its life history is known, alone to be found naturally in the animal body.

4. The bacillus is, however, of very tenacious vitality, and will preserve its virulence and capacity for development for six weeks or longer in decomposing sputum, for six months or longer in the dry state.

5. If a minute portion of bacillus-containing matter be placed upon a neutral culture-surface and allowed to germinate, and if a fragment of the product of germination be similarly cultivated on a fresh surface, and so on for many generations, all foreign germs being excluded, the last product, if inoculated into an animal, will be as potent in producing tuberculosis as the first.

6. The bacilli, whether derived from free cultivation or from tubercle, if intimately diffused in water and scattered in the form of spray through an atmosphere in which animals are placed, so that they inhale it, will produce tuberculosis in them.

The following is a summary of our knowledge respecting the distribution of the bacilli in the lesions of phthisis.

7. In the sputa of all well-marked cases of phthisis the bacilli are to found.

8. In cavities in the lungs of tubercular or caseous pneumonic origin (*i.e.*, of phthisical origin), whether large or minute, bacilli are invariably to be found.

9. In caseous and catarrhal pneumonic consolidations of the lung, excepting in the immediate neighborhood of cavities, large or minute, bacilli are sparse and rather difficult to find; large fields of sections may be traversed without discovering them; yet this material is virulent in producing tubercle when inoculated.

10. In the granulations of miliary tuberculosis bacilli are very generally, but not invariably, to be found, and often only in small numbers.

11. The results of inoculations made with dry bacillus-cultures by Koch and many others, with the most minute precautions, have with much reason been accepted as proving the micro-organism to be *per se* the virus of tubercle. These results have not altogether escaped challenge, however, it being thought by some that a chemical poison might still cling to the bodies of the bacilli, and be the essential virus, of which, then, the bacilli would be only the carriers.

It does not seem best, within the limits of such an article as this, to attempt to depict in detail the minute anatomical changes which precede or accompany phthisis, inasmuch as this would involve giving the pathological anatomy of bronchitis and peri-bronchitis, catarrhal and croupous pneumonia, tubercular new-growths throughout all their changes, interstitial pneumonia, etc. Many

are familiar with the subject, and others can study it to better advantage in works devoted exclusively thereto and abundantly illustrated.

On opening the chest of a person who has died of pulmonary phthisis, we shall find areas of consolidation of the lungs, of various sizes, generally diffused or more localized, in every stage of formation, decay, and removal; the pearly new-growth, the cheesy mass, both within and without the air-chambers, and cavities of varying size and contents. We may also see the evidences of contracting interstitial pneumonia, cicatricial formations, and pigment induration. Everywhere, likewise, we shall find the tubercle-bacillus.

It is often impossible, at the autopsy, to say which of the earlier processes began first. According as one is a more or less enthusiastic advocate of the bacillar theory, he may conclude, on the one hand, that all the varied processes before him were originated by the presence of the tubercle-bacillus, or, on the other hand, that the catarrhal pneumonic changes began first, owing to ordinary causes such as induce simple pulmonary inflammation, and that the retained products of such inflammation were then invaded by the bacillus, causing the destructive changes that followed.

Before dismissing the subject of etiology, several important points remain to be considered, such as:

Contagion.—There have always been those who have taught the contagiousness of phthisis, and have pointed to instances where husband and wife have successively fallen victims to the disease, or where an apparently healthy person has developed phthisis after nursing a patient with the same. Our present knowledge of a living infectious organism gives still greater probability to this theory; in fact, we are forced to the conclusion that the sputa of phthisical patients furnish the most frequent source of infection. It is right that we should act upon this knowledge, so far as the careful isolation and destruction of such sputa is concerned, and the avoidance of unnecessary and very close contact with phthisical subjects—especially on the part of children or delicate persons—as in the act of kissing, the occupancy of the same sleeping-rooms, etc. But, after all, the immense amount of clinical observation on this point, at the command of every experienced practitioner, must convince us that the danger is far less than would at first appear, and that here the exceptions almost disprove the rule.

Predisposition.—In view of the universal dissemination of tubercle-bacilli that must exist in the world, we are surprised that the victims of phthisis are not even more numerous than is shown by our present sad statistics. We must suppose, then, that the majority of people are not susceptible to contagion, and that in order to infection there must be a predisposition thereto. Wherein, exactly, this predisposition lies, we are unfortunately not able to say.

Heredity.—Few will be found to admit that phthisis is hereditary in the same sense as syphilis. But, on the other hand, the liability of this disease to "run in families" is undeniable. We can hardly suppose that living germs are conveyed from parent to child before birth, to lie dormant in the latter for from fifteen to thirty years, and then to develop phthisis. In the present state of our knowledge, we can only assume that a certain weakness of constitution descends from one generation to the other—a tendency to defective nutrition—whereby, if the child does not succumb early, it is more liable to do so at the age of puberty; under the influence of confinement at labor or study, or of the dissipations of youth; during the period of early child-bearing, or the first strain of a man's independent business life. Then the exposure to tubercular contamination, from which others escape, claims its unresisting victim. This general statement probably does not contain the whole truth, but it must be left to future investigation to develop this with greater exactness.

Geographical Distribution and Climate.—While phthisis may be found the world over, yet it is certainly far more rare at an elevation of over 2,000 feet above the sea-level, and also less frequent in regions characterized by a dry atmosphere and porous soil at any elevation. Next to the unfavorable influence of low-lying, damp regions, is the crowding together of people, as found in larger towns and cities. This of itself, as a rule, implies more confinement within doors, more artificial methods of life, and the multiplication of bad hygienic surroundings. It is within the experience of the writer to have seen regions in Western Missouri, Kansas, and Texas, where, thirty years ago, it was claimed that phthisis was never developed, and where now, in the cities at least, new cases are developing continually. How far this may prove hereafter to be the case in the cities lying more than 4,000 feet above sea-level, remains to be seen.

Everything that favors catarrhal conditions of the respiratory mucous membrane, indirectly favors the development of phthisis. Hence milder and more equable climates are preferable to rigorous and changeable ones, especially at or near the sea-level. In the mountain regions of the centre of our continent, and probably elsewhere, the annual or diurnal range of temperature seems to play a less important part.

Age, Sex, Occupation.—While no age is exempt from phthisis, the period when it is most likely to be developed is from 15 to 30. Both sexes are about equally involved. Occupation exerts considerable influence; indoor occupations being as a rule unfavorable, and the so-called dust-occupations especially so. Stone-cutters, instrument-grinders, coal miners, and many others who are employed in an atmosphere laden with especially insoluble dust, show accumulations of the same within the lungs, and become liable to phthisis.

From all that precedes it is evident that phthisis is essentially a disease of civilized life, prevailing chiefly where people are most crowded together; in commercial and manufacturing centres rather than in agricultural or pastoral regions; and found least of all among savage and nomadic tribes, without regard to climatic conditions. In connection with the latter statement, it is to be noted that among the Indian children and youth who of late years have been taken from their homes in the West to be educated at Carlisle, Pennsylvania, and Hampton, Virginia, there has been a very great mortality from phthisis. Statistics are not available to show what ratio of mortality from this cause might obtain among the same number of Indian youth living with their tribes. Many causes, among them alcoholism and syphilis, combine to lower the standard of health among our aborigines. Still there can be but little doubt that a change of climate to the Atlantic seaboard and altered (more civilized) methods of life have much to do with this mortality.

General Symptomatology.—The onset of the disease is usually gradual, both in those cases in which the earliest symptoms belong to the respiratory apparatus, and in those which are characterized by a general failure of the vital powers preceding any respiratory troubles. In the latter class, the patient may only complain of weakness and loss of appetite, at the same time growing pale, losing in weight, and being short of breath. On examination he will be found to have a pulse of 100, with probably a slight afternoon rise of temperature, say to 100.5° F. These are the cases that are often treated by physicians as well as friends, as "indigestion," "chlorosis," or "malaria," until perhaps the development of a severe cough, of night-sweats, or of hæmoptysis reveals the true seat of the disease. Careful physical exploration of the chest, however, would in most instances have revealed the actual state of things much earlier.

More commonly the invasion of phthisis is marked by a slight but persistent cough—continuing for weeks or months, perhaps, before the appearance of slight hectic fever and beginning emaciation—persistently rapid pulse, languor, dyspnœa on exertion, occasional night-sweats, perhaps occasional slight streaks of blood on the sputa, or possibly a distinct pulmonary hæmorrhage. These symptoms may, at a very early date, be accompanied with constant dull pain in the chest, or with occasional sharp stitches, or there may be no pain at all throughout the course of the disease. A patient placed under appropri-

ate hygienic conditions and treatment during this early period of the disease, will almost always improve, and his friends will feel much more confident of his recovery than does the experienced physician. A permanent change of residence to some high and dry locality, combined with an outdoor life, will often effect a cure at this time—that is, the progress of the disease will be arrested, small cavities will cicatrize, and the individual will live out what life insurance companies call his ordinary expectancy. But more commonly, where these favorable conditions cannot be secured, the improvement is only temporary, usually lasting for a few months. Then cough, expectoration, fever, sweats, all return in a more decided degree than before, and are accompanied in all probability by symptoms of dyspepsia. Another less complete rally follows, only to give place to a further relapse, until, after months or years, it becomes evident that it is only a losing fight; emaciation still progresses, the voice is lost, swallowing becomes painful, œdema of the extremities appears, the harassing cough never abates, and the dyspnœa grows worse, till the exhausted victim welcomes death as a happy release.

There is another class of cases—very appropriately called acute disseminated phthisis (the phthisis florida of the Germans, the galloping consumption of the French)—which usually begin with urgent pulmonary symptoms, such as great dyspnœa and violent cough, together with hectic fever and sweats, or continued fever. These cases differ further from the ordinary cases of phthisis merely in the fact of their uninterrupted progress toward a fatal end—which is usually reached within a few months, sometimes even within a few weeks. The later symptoms of the more chronic form are here undeveloped, merely through lack of sufficient time. These are the cases which neither medicines nor change of climate influence favorably. That they are tubercular or bacillar we cannot doubt, and yet they must not be confounded with acute general miliary tuberculosis. The latter disease involves many other organs besides the lungs; the tubercles within the lungs are usually not broken down, and there are no bacilli in the sputa; whereas in acute disseminated phthisis the destruction of lung-tissue is generally very extensive.

Individual Symptoms and Complications.—*Cough.*—This is usually present from the beginning to the end of the disease, being one of the greatest sources of annoyance to the patient, often depriving him of his rest at night. The cough varies with the fluctuations of the disease, lessening as the patient improves and increasing as he relapses. The more the larynx is involved, the more violent the cough becomes, and the more likely is it to terminate in vomiting. It would perhaps not be worth while to mention so familiar a symptom at all, were it not for the sake of cautioning the young practitioner not to be deceived by its absence, for sometimes this anomaly does occur. Very rarely a case of phthisis advances quite far with practically no cough, entirely deceiving the patient and his friends, who think that there can be nothing the matter with the lungs of one who does not cough.

Expectoration.—This varies considerably in different patients and at different stages of the disease. Some, indeed, for a long time have only a dry, hacking cough, which of itself is a suspicious circumstance, since most cases of bronchial catarrh afford early secretion and expectoration. This very product of bronchial catarrh, frothy muco-pus, often constitutes the sputum of phthisis in its earlier stages, affording nothing characteristic in its appearance. If there is considerable pneumonic disturbance the sputum will partake of the vitriform, glutinous character peculiar to that disease, without, however, generally being rust-colored. Spots and streaks of blood upon the expectoration are not very rare, and, if occurring repeatedly, should always challenge attention and careful exploration of the chest. Any more considerable admixture of blood is, of course, still more significant, and will not fail to alarm the patient and his friends. Later in the disease the expectorated matter assumes a more solid, globular form, sinking in water—the so-called nummular sputa. These globular masses are thought by some to have their origin in cavities and to prove the existence of such, but this is hardly consistent with the evidence given by auscultation in many such cases. The only unequivocal evidence of cavities given by the sputa consists in the presence of elastic tissue-fibres, to be mentioned again later. At a more advanced stage it is not unusual for the expectoration to be very profuse, consisting almost entirely of liquid pus, sometimes fetid, but more frequently not so. This comes both from the bronchial tubes and from lung-cavities.

Miscroscopic examination of the sputa, carefully and repeatedly conducted by one skilled in the procedure, will show the presence of tubercle-bacilli in both the earlier and the later stages of the disease. The presence of elastic tissue-fibres belongs only to the stage of cavity formation. The attempt will not be made here to teach the technique of bacillus staining, this subject having been fully discussed in the preceding volume (p. 763 *et seq.*). In the matter of discovering the elastic fibres, Strümpell says: "We are most sure to find them if we look in the sputum, when spread out, for little lentiform particles which can easily be discerned with the naked eye. These consist of necrotic shreds of tissue torn from the walls of cavities. If we press one of these kernels under a cover-glass, we often find, in the midst of the granular detritus, beautifully twisted elastic fibres which often have quite a definite alveolar arrangement."

Fever.—Now and then a case of phthisis is reported as having run its course almost without fever. As a rule, however, there is a distinct rise of temperature in the afternoon, sometimes twice a day. Ordinarily it is not high, perhaps not over 100° F.; but whatever be its height, it continues to recur with great and monotonous regularity month after month. Often the range is higher for a time, reaching even 103° or 104° F. during the exacerbation, but still remaining at the normal during a good many hours of the day. The so-called cases of fibroid phthisis are the ones accompanied by the least fever—apparently none at all, in many instances, until the period of final breaking down.

Emaciation.—This is very striking in most instances, and is continually progressive unless the advance of the disease is temporarily arrested. The fluctuations of body-weight are a fair index of the general condition of the patient.

Night-sweats naturally accompany the hectic fever. They are not so much a cause of weakness—a conviction firmly held to by the laity—as they are an evidence of prostration, and of the profound involvement of the entire system.

Hæmoptysis.—This may occur at any stage of the disease. Not infrequently it is the first sign of danger to attract the attention of the patient or his friends, and it may recur often; while, on the other hand, a good many cases run their course to a fatal end without hæmoptysis ever having occurred. The amount expectorated also varies from a mouthful or two, to a pint. Hæmorrhages from the lungs by no means always follow undue exertion or severe coughing on the part of the patient; indeed, many of them occur during the night. Although it is always an alarming symptom, yet death directly due to hæmorrhage is rare. Some people suffer from repeated and very severe hæmorrhages, while yet the course of the disease does not seem to be specially hastened or unfavorably influenced thereby. The theory of the usual origin of hæmoptysis in the branches of the bronchial artery is now generally discredited, while the branches and capillaries of the pulmonary artery are believed to be the parts involved. Powell says (*op. cit.*): "The majority of cases of fatal hæmoptysis have been found to be due to the rupture of a pulmonary aneurism in a cavity. Ulcerative erosion or rupture of large pulmonary vessels within cavities accounts for the remainder of the cases." Lesser losses of blood may be due merely to active inflammatory hyperæmia, or to the softening of the walls of minute vessels by nuclear proliferation within the same. It is no longer believed by most men that a bronchial hæmorrhage is the cause of phthisis, through

the blood accumulating in the air-cavities of the lung and there setting up inflammatory changes. We hold that the hæmorrhage is evidence of previous phthisical changes in the lung, which may sometimes have escaped notice, even on the part of very experienced examiners. (See also the article on Hæmoptysis.)

Indigestion and Diarrhœa.—These two complications are mentioned together, not because they are liable to occur at the same time or in the same person, but merely because they both belong to the digestive apparatus. Indigestion is a very common accompaniment of phthisis, sometimes preceding the pulmonary symptoms in such manner as to cause an error in diagnosis. Usually it only amounts to decided loss of appetite, distress at the stomach after eating, eructation of gases, and sometimes vomiting or pain. Later there is decided intolerance of certain articles of food, and as a result the patient's diet list may be so restricted as materially to interfere with his nutrition. The disturbance within the stomach caused by the presence of food also seems to incite cough. Diarrhœa is usually quite a late symptom, and is said to be caused sometimes by a mere intestinal catarrh, and sometimes by the presence of tubercular ulcers within the intestinal canal. Once begun, it usually persists, and hastens the fatal termination.

Laryngeal Symptoms.—These sometimes appear early, but usually they develop at a later stage. There may be merely the hoarseness and irritating cough of subacute laryngitis, and this is quite as likely to take place early. Or there may be tubercular ulcers within the larynx, causing extensive destruction of tissue and untold suffering. There is no doubt that this is, as a rule, a late complication, appearing only when extensive destruction of lung-tissue has already taken place. Still there are good laryngologists who teach that primary tubercular laryngitis is not rare, the disease passing thence downward to the lungs. The possibility of this no one can deny, and it undoubtedly does sometimes occur, but not often.

When extensive or deep ulceration occurs deglutition soon becomes very painful, and food also may find its way into the larynx, causing violent paroxysms of coughing. The intense pain on swallowing and the liability to strangle make the patient dread any attempt at eating, while yet he suffers from hunger. If laryngeal trouble occurs very early in phthisis, the use of the laryngoscope will be requisite for diagnosis, and then the peculiar club-shaped thickening of the arytenoid protuberances will be found especially characteristic. In the later stages the diagnosis is plain enough, even without the mirror.

Other complications of phthisis may, of course, arise, varying greatly according to climate and individual circumstances. Those given above are the most common. For a discussion of "syphilitic phthisis" the reader is referred to the article on Syphilis.

Diagnosis.—The diagnosis of pulmonary phthisis from the rational symptoms need not here be discussed, as this would involve merely a review of what has immediately preceded. In addition to this we have the physical signs, which will presently be discussed. These help us greatly in the early recognition of the disease, in locating areas of consolidation or cavities, and in following the progress of these changes. Valuable as are the results of auscultation and percussion in many cases, they are also sometimes very obscure, and I have long held that, if I had to depend on the rational symptoms only, or the results of auscultation and percussion alone, for my diagnosis, I should unhesitatingly choose the former. Fortunately, however, we may invoke the aid of both. The most unequivocal evidence furnished, when it is present at all, lies in certain conditions of the sputa, viz., the presence of the tubercle bacillus or of elastic fibre. The bacillus may be found both early and late, while the elastic fibres are confined to the stage of cavity formation.

Physical Signs.—In considering these it is only necessary to take into account the evidence given by percussion and auscultation. All consolidations of the lung give dulness on percussion, differing in degree according to the area of the consolidation. In phthisis these areas are usually small and are situated at the apex of one or both lungs; therefore we expect to find dulness, slight or moderate, at either one or both apices. This is usually confined to a space extending from one to two fingers' breadths below the clavicle on the affected side, and is best elicited by rather gentle percussion. When dulness is present it is a sign of value. Its absence, however, must not be depended on as proving the integrity of the underlying portion of lung, for a compensatory emphysema may so overlie the consolidation as to give good percussion resonance. Sometimes, it is true, this condition affords a note of "tympanitic dulness," but at other times it is impossible to distinguish it from the normal sound.

Auscultation.—Speaking of the signs of the "earliest recognizable stage of phthisis," Powell (*op. cit.*) says: "The respiration is weaker at one apex, the inspiration being wavy or even jerking. There are usually a few ronchi present which, if limited to that apex, are very significant; and, in addition, there is heard at the extreme summit of the lung (supra-clavicular or supra-spinous region) a peculiar crumpling sound at the moment of cough, which differs both in time and degree from the crepitant sound heard at a somewhat later stage with the first inspiration following a cough. These physical signs, which are but very slight—and their recognition is of the more importance on this account—are those of a bronchial catarrh limited to one apex, associated with a decided imperfection of the respiratory murmur at that apex, which, when taken in conjunction with the symptoms—more particularly emaciation, quick pulse, and evening pyrexia—afford unmistakable evidence of incipient phthisical disease." Besides the weakened inspiratory sound and the wavy or jerking inspiration spoken of above, a prolonged, harsh expiratory murmur is also one of the earliest signs. At the same time, or very soon afterward, or in some other patient at an apparently equally early stage of the disease, crackling râles may be heard in the supra-clavicular or supra-scapular regions. These may, perhaps, be audible only when the patient takes an unusually deep inspiration, or after he has coughed, but when present they are very characteristic of phthisis.

Sooner or later evidence will appear, by the same signs, of the extension of these changes to adjacent portions of the lungs. The crackling râles, especially, will extend, and moister sounds will here and there take the place of the dry râles heretofore heard. At the apex, or over the part first affected, bronchophony and bronchial breathing will become more distinct. Finally, evidences of cavity-formation may appear. The demonstration of the existence of a cavity is sometimes easy and sometimes extremely difficult. If we get a clear or tympanitic percussion-note and distinctly amphoric breathing, the matter is plain enough. "Metamorphosing respiration" is that which begins as a normal vesicular murmur and suddenly breaks off into bronchial breathing. This is also heard over a cavity. After all, next to amphoric breathing and voice-sounds, the most unequivocal evidence of a cavity is given by loud, bubbling râles.

In fibroid phthisis, or cirrhotic contraction of the lung, which is usually unilateral and very slow in its progress, the chest-wall of the affected side will be found contracted and comparatively immovable. Percussion resonance is usually quite dull over a large part or the whole of that side of the chest. The vesicular murmur has almost disappeared, and in its place we find loud, harsh bronchial breathing, sometimes accompanied by sibilant, but more frequently by moist, râles.

Wherever there is consolidation, be it much or little, there will be increased conduction of voice-sounds and greater vocal fremitus. The greatest value of this sign is in those cases of beginning consolidation at an apex where percussion dulness is not very evident, and where râles are very slight or quite absent. Here the increased vocal resonance elicited by causing the patient to count aloud in a firm, uniform tone, repeating the numbers up to three or five, while the ear is applied over the supra-

scapular space, is often very marked and of great value in diagnosis.

In all these remarks it is only attempted to give the most salient points in physical diagnosis. Many very interesting finer differentiations must be left to be looked up in more elaborate treatises on this subject.

Prognosis.—Everyone is familiar with the unfavorable termination of most cases of phthisis, and with the very large share which this disease takes in all mortality statistics. Even physicians are liable to look upon the well-established diagnosis of phthisis as almost equivalent to the death-warrant of the individual. This, however, is not correct. While it is difficult to furnish statistical data on the subject, it is certain that many cases of phthisis recover. We were wont to believe that cases of inflammatory origin might recover, while those in which tubercle was present were almost sure to end fatally. The presence of the tubercle-bacillus, however, does not seem to indicate anything necessarily very serious in the prognosis. Already we have well-authenticated cases of apparent recovery where the presence of the bacillus had been demonstrated. Under favorable climatic, hygienic, and domestic conditions, where the disease is not advanced to its later stages, we are justified in giving considerable hope of recovery, or at least of such repair as will enable the individual to live out his ordinary expectancy in moderate comfort, so long as these favorable surroundings are maintained. Many circumstances, of course, modify the prognosis. The stage of the disease is of great importance, and yet even quite advanced cases, with large cavities and the most profound general disturbances, sometimes recover. In order to form an estimate of the probabilities of any given case, it is essential that the physician should watch it for some little time. Hereditary predisposition influences the prognosis rather unfavorably in any event, but especially when the disease is already well established. Considerable extension of the tubercular process, even though in the first stage, is unfavorable; so is early emaciation, or the maintenance of a continuously high temperature. I do not think that the occurrence, or non-occurrence, of hæmoptysis has any special bearing on the probabilities of recovery.

Treatment.—Under the head of prophylaxis everything is to be included which tends to avoid disease and to build up the individual, viz., good, easily digested, nutritious diet, warm clothing, sponge-baths, well-ventilated sleeping-rooms, and plenty of sunshine and of out-door exercise. Erect carriage of the body is quite important, and is aided by such gymnastic exercises, not carried to excess, as specially develop the muscles of the chest. Where there is any hereditary predisposition to phthisis, all these things are very important. By paying heed to them, and if possible, by adding to them the advantages of a favorable climate, many a child grows up to healthy maturity that would otherwise develop phthisis at the age of puberty or soon after. Dr. Frederick C. Shattuck, of Boston, Mass., in an editorial note to the translation of Adolf Strümpell's "Text-book of Medicine" (New York: D. Appleton & Co., 1887), says: "In 1857, 39.50 deaths from consumption were returned, in the State of Massachusetts, for each ten thousand of the population; in 1883, 29.90. This decrease is too large to credit to greater accuracy in diagnosis, and to the transference of consumptives to other States, and is mainly attributable to the prevention of phthisis by improved hygiene. Still, it seems fair to carry some of the improvement to the account of the arrest and cure of actually developed disease, through early diagnosis and more rational treatment, hygienic as well as medicinal."

The question of the contagiousness of phthisis has already been discussed. In view of what has been proved concerning the danger that accompanies the inhalation of tubercle-bacilli from dried sputa, we can no longer regard with indifference the disposition to be made of the sputa of phthisical patients. Spit-cups and receptacles of every kind for the sputa should contain strong germicide solutions; handkerchiefs or cloths used for the same purpose should be immersed in such solutions before being mixed with other clothing. While nothing need be done to isolate phthisical patients, and render their hard lot still harder, reasonable prophylaxis demands that no one shall occupy the same bed with the patient, nor even the same sleeping-room if it can be avoided; and these precautions are doubly important as applied to the children of the patient, to persons already suffering from lesions of the respiratory mucous membrane, or to those who may be supposed to be specially liable to phthisis.

In the prophylaxis against the disease, as well as in its treatment when developed, the maxim holds good: "Pure, fresh, untainted air, at all hours, at all times, and in all places, is the one condition with which nothing should be allowed to interfere!" It is, alas, far easier to utter or to subscribe to such a sentiment than it is to find the pure, untainted air! But it is worth something to know what we are aiming at, and, if we cannot quite hit the mark, to come as near to it as possible. So it goes without saying that pure air is not to be found in crowded habitations, nor in work-shops, nor in school-rooms, nor, for that matter, in a crowd anywhere; it is not, as a rule, so readily found in the city as in the country, though in the latter, too, sources of contamination are abundant and must be looked for and avoided. This matter of pure air plays a prominent part in all our "climate cures" of phthisis, the only method of cure of which we can speak with any confidence. It is not my purpose here to enter into any discussion of the various elements that go to make up climate—elevation, temperature, humidity, rainfall, sunshine, winds, etc.—nor to consider the influence of different kinds of climate on persons of different temperaments, or even on those suffering from the disease which we are studying. The subject, even in its most restricted form, is far too wide for consideration here, and has indeed been partly considered in other portions of this Handbook. Every man of any experience in handling phthisical patients learns, among other things, that they generally bear cold badly; that they certainly do badly in raw, damp weather; that they do best when they can be out of doors most. Hence the evident need, if possible, of banishing them, during the winter season at least, from the lower plateaus, or the more northerly latitudes of our land; and if, during the entire year, they can be established in a moderately elevated, dry, sunshiny, not too rigorous climate, they will be doing the best for themselves that can be done. There are many good health-resorts in this country, among them the Adirondacks, Atlantic City, Aiken, S. C., Florida, San Antonio and El Paso, Texas, the whole of New Mexico, and many places in Colorado and Southern California. With all of these excepting the Adirondacks and California, the writer is personally familiar, and he has no hesitation in saying that, in the long run, the climate of Colorado will do the most good to the largest number of consumptives. Dr. Hermann Weber, in his well-known work on Climate, says that mountain regions are not well suited to persons who easily become feverish from slight causes, as from errors in diet, excitement, fatigue, "taking cold," etc., but that such do better at the milder and more equable sea-side resorts. It has also seemed to me that patients with comparatively early and grave involvement of the larynx derive less benefit than others from a refuge in the mountains. I have, however, also known some very notable instances to the contrary—persons who had not done well in the South, and who improved greatly in Colorado. A tendency to hæmoptysis is no longer regarded as forbidding a residence in the mountains.

As has already been intimated, the limits of this article forbid a general discussion of the subject of climate in phthisis, or of special health-resorts in this country. Much could be said in favor of all such places. It may, perhaps, be permissible to add that to most of our Northern people Southern resorts fail to furnish such diet and domestic comforts as to render them contented for any great length of time. In Denver, Colorado Springs, and Manitou, on the contrary, all these are easily secured, together with the services, if needed, of exceedingly intelligent and competent physicians.

There is no doubt whatever in my mind that the climate treatment of phthisis is worth more than all other treatments put together. Every health resort for consumptives, of any deserved reputation, can point to numerous instances of persons living there in comparative health and comfort (often in apparently perfect health), who were brought there in various stages of well-developed phthisis, and who, but for such climatic treatment, would have been dead years ago.

Aside from climatic treatment, the general conditions of malnutrition present in phthisis may often be favorably modified by the use of certain medicinal agents. Prominent among these is *cod-liver oil*. In spite of all the opposition that has of late years been raised against the use of this remedy, there is no doubt that it has helped to save the lives of thousands of tuberculous or strumous patients, and will continue to do so. There are many elegant preparations of the drug now in the market, in which its disagreeable odor is sought to be covered. In many of these the emulsion of oil is combined with the hypophosphites of lime, soda, manganese, etc. There is no objection to this combination provided the requisite amount of cod-liver oil be present. One of the best combinations is that of the oil with Trommer's extract of malt. Although not disguising the odor of the oil, the malt aids materially in its digestion as well as in the digestion of food, and patients taking this preparation will usually improve in appetite. I do not believe that the use of cream, of glycerine, or of other fats will take the place of cod-liver oil.

General tonics, such as *iron*, *quinine*, *arsenic*, etc., may often be used as valuable *adjuvants* in the treatment of phthisis, but nothing more. Much is still claimed for arsenic by some very good men, and it is possible that a more general and more liberal use of this drug might be of advantage; certainly, it could do no harm if carefully watched. The man who hopes to cure phthisis by giving large doses of quinine (gr. xv. to lx.) to reduce the fever, is not fit to practise medicine.

A much more vexed question is that of the use of *alcoholic stimulants*. Whatever may be its ultimate mode of action on the processes of nutrition, there is no denying that, under the use of alcohol (preferably employed in the form of whiskey), phthisical patients will improve in general condition, gain in weight, eat more, and cough less. In many cases this method of treatment has begun an improvement which change of climate, or improved hygienic conditions and habits of life without change of climate, have confirmed, and the patient has gone on to recovery fully persuaded that whiskey saved him. Unfortunately, however, in a deplorably large number of instances, the use of whiskey is not stopped when the need for it ceases, and the person who has escaped phthisis becomes a confirmed inebriate. Better to die with the former than live the latter! A great responsibility, therefore, rests upon the physician who ventures to prescribe alcoholic stimulants in so chronic a disease as phthisis. If they are to be given at all, it should always be as a vehicle for cod-liver oil, or for iron and quinine, or in some other way prepared as a not-too-palatable medicine, to be taken only at stated times, and never as a beverage.

The treatment of consumption by the use of the hypophosphites of lime, soda, etc., which was introduced by Dr. Churchill, of Paris, some years ago, has not afforded any results worth mentioning. The same may be said of many other plans of treatment not worthy of specific enumeration. Some more recent methods, however, may be noticed, although they are as yet only on trial. First among these we mention the introduction into the system of the *bacterium termo*, a microbe of great destructive energy, and the special hunter and exterminator of the tubercle-bacillus. It is claimed, doubtless with truth, that after the introduction of the termo-bacterium, tubercle-bacilli well nigh disappear from the sputa, while the patient, to say the least, grows no worse. This plan of exterminating one species of microbe by another may yet be made something of, but hitherto it has yielded no results in the way of cures. The *pneumatic cabinet*, with its treatment by compressed or rarefied air, is not constructed on as new a principle as the makers of such apparatus would have us believe. Waldenburg's method, and the use of air-tight chambers with variously modified atmospheres, have been tried in Europe for fifteen years. Undoubtedly patients often improve for a while under this treatment, otherwise it would have been utterly discarded long ago; but, undoubtedly also, as a rule, they do not experience any great or lasting good, otherwise the method would ere this have been generally introduced.

The *injection into lung-cavities* of antiseptic solutions (as a five to ten per cent. solution of carbolic acid) has engaged the attention of the profession more or less for several years. Of late, the number of cases reported has materially increased, and in some instances the improvement of the patient's general condition, as well as of the local lesion, has been all that could be desired. No serious ill-effects have ever followed the operation, while on the contrary, cough and expectoration have diminished, and, in some cases, the healing and filling up of the cavity has been apparent from the physical signs. It is an expedient well worthy of being attempted where cavities are superficial, and where the treatment is found to be well borne. Such injections should not be undertaken oftener, as a rule, than once a week.

The last novelty in the way of treatment is one introduced by Dr. Bergeon, of France, and consists in the introduction into the rectum of carbonic acid gas charged with sulphuretted hydrogen. This, being absorbed, is promptly eliminated through the lungs, thus taking the bacillus in flank and rear with a steady, though very gentle, sulphurous current, and generally disinfecting the diseased parts. Those who have tried it are unanimous in testimony that their patients improve in every way, feeling better, gaining in appetite and in weight, losing their night-sweats, and coughing less. The method has not been tried long enough to demonstrate whether it will prove to be of permanent value to those subjected to it.

In addition to what is done for the cure of the disease generally, the following symptoms require special consideration.

Cough.—The temptation is very great to prescribe some sort of a mixture for every cough. It is, however, well to avoid this, so far as possible, in the earlier history of phthisis, inasmuch as mild preparations and expectorants do very little good, and often disturb the stomach; and opiates should be reserved till a later stage. If something is imperatively demanded by the patient, the muriate or carbonate of ammonia in small doses, given in syrup of marshmallow, with perhaps a little paregoric added, will do as well as anything. When it is really necessary to try to quiet the cough, either by day or by night, it is well at first to try the effect of the extract of lactucarium, gr. ij. or iij. at a dose, or gr. j. to ij. of the extract of hyoscyamus. For a quieting draught at bedtime, ten to thirty grains of chloral hydrate, with double the quantity of bromide of potassium in simple elixir, will do for a while. Before resorting to the stronger preparations of opium, the sulphate of codeine may answer for a time in doses of $\frac{1}{4}$ to $\frac{1}{2}$ grain.

At last, however, we shall be forced to come to the use of opium or morphine, and once begun, it will be continued in somewhat increasing doses to the end. In the earlier stages of the cough, relief may sometimes be experienced from the inhalation of the vapor of boiling water loaded with the fumes of liquid tar which is poured into the water. An ordinary spirit-lamp and tin cup are all the apparatus needed. Gargling or brushing the throat with a strong solution of chloral sometimes quiets the excessive tickling which is referred to the pharynx.

Fever.—Of late the fever of phthisis has been more successfully treated with antipyrine in fifteen to thirty-grain doses, once or twice a day, than it ever was with quinine. Probably antifebrine in five to ten-grain doses would answer equally well. Quinine is notoriously worthless, and large doses are decidedly objectionable.

Night-sweats.—If the hectic fever is controlled the sweats do not occur. Otherwise, they are best held in check by gr. $\frac{1}{120}$ to $\frac{1}{60}$ of sulphate of atropine, given from one to three hours before the time of sweating.

The dyspepsia of phthisis is relieved for a time by the same things that would help other dyspepsias—pepsin, hydrochloric acid, pancreatine, extract of malt, etc.

Hæmoptysis.—It is quite important that the physician called to a patient suffering from hæmoptysis should be calm and quiet in demeanor, thus convincing the frightened patient, more even than by his verbal assurances, that there is but little, if any, immediate danger from the hæmorrhage itself. Often it will be necessary to stop the administration of alcoholic stimulants already begun by anxious friends. Even though the patient be pale, with feeble pulse, cold extremities, and clammy sweat, it is usually not wise to give stimulants; for increased heart's action, brought about by that means, implies increased liability to a recurrence of the hæmorrhage. Let the blood be invited to the surface of the body and to the extremities by the external application of heat, while cold compresses or ice-bags are placed over the upper part of the chest. The best stimulant in such cases is half a grain to a grain of opium, and one to two grains of camphor. This quiets nervous excitability and alarm, sustains, while it does not excite, the heart's action, and checks cough—which is often quite an important item. Whether the opium be called for or not, few men now-a-days would venture to treat a case of hæmoptysis without giving from half a drachm to a drachm of the fluid extract of ergot, every hour at first, and later every two, three, or four hours; though, to tell the truth, it is very hard to recognize any palpable effect of this drug. At the Brompton Hospital for Consumptives, turpentine in twenty-minim doses is often found to answer a good purpose when ergot fails. I believe that acetate of lead and other astringents thrown into the stomach do no good, and often much harm. It is almost needless to say that the patient must be kept absolutely quiet in bed, guarded from mental disturbance, hardly permitted to talk for a while, and must not be disturbed by the attending physician for the sake of any exploration of the chest that he might find it interesting to make. Very few patients die of hæmorrhage.

Laryngeal Ulcers.—One of the most distressing accompaniments of phthisis is ulceration of the laryngeal mucous membrane, causing, as it does, not only aphonia and loss of expulsive power in cough, but great pain and difficulty in swallowing. In the earlier history of this trouble great good sometimes results from the application of a solution of nitrate of silver, twenty grains to the ounce. This probably does more to relieve the laryngitis than to cure the ulceration.

At a later stage insufflations of one part of morphine or cocaine, four parts of iodoform, and five parts of powdered tragacanth, afford considerable relief. When the pain in swallowing is very severe the larynx should be brushed, shortly before eating, with a ten per cent. solution of muriate of cocaine. Either the patient himself or some of his friends can usually learn to make this application.

So little has been said of all the thousand things that go to make up the care and treatment of a patient with pulmonary phthisis, that the writer is thoroughly dissatisfied with this portion of his paper. He must content himself, however, with two practical suggestions in closing.

First, many phthisical patients with delicate appetites, or with good appetites and poor digestion, would do better if fed five or six times a day rather than three times. They should have a glass of milk or a milk-punch brought to them before rising in the morning, milk or koumyss, a raw egg with a glass of sherry, beef or mutton broth, or something light and easily taken, between breakfast and dinner, between dinner and supper, and the last thing at night.

Second, patients sent to a health-resort, or changing climate for the benefit of their health, should be placed under the supervision of a medical man, who may advise them as to the regulation of their life under the new conditions in which they find themselves. They need someone to tell them how to eat and how to sleep, how much and what sort of exercise they shall take, what to avoid as well as what to do.

For the lack of this sort of guidance and watching, many fail to secure the benefits they might from a change of climate, some are positively harmed, and some, who at first did well, fail to adjust themselves to their changing physical conditions, and foolishly think that they have "worn out the climate."

Edward W. Schauffler.

PHYSICAL MEASUREMENTS. The systematic mensuration of the human body has, until within a few years, been the work chiefly of military and naval medical officers, whose inquiries seldom extend beyond the few points called for on the descriptive list of the individual soldier, sailor, or marine as a means of identifying him; and this in the interest of the Government, to facilitate his recovery if a deserter, or to protect itself against fraud if he is an applicant for pension. The records of the medical examiner, consequently, comprehended only the entry of the name, age, weight, height, color of hair, eyes, and complexion, and prominent personal marks, and the individuals measured were mainly adult males within the enlisting or shipping ages, with the few adolescents who became apprentice or music boys, or cadet pupils at the national academies.

The greater attention recently given to physical culture, as a consequence of the general recognition of the importance of sanitary considerations, has suggested the necessity for some better knowledge of human physical constants, and attempts have been made by Dr. Bowditch in the Boston public schools, Dr. Sargent at Harvard University, Dr. Hitchcock at Amherst College, Dr. Hartwell at Johns Hopkins University, and other medical men interested in the physics of the body, to obtain statistics of human growth and development. Dr. Bowditch alone has been able to include both sexes among his data, but it is understood that Dr. Sargent will soon be able to publish the results of the measurements of several thousand females.

While on duty in charge of the medical department of the United States Naval Academy (1875–80), it occurred to me that the opportunity there existed for obtaining information that would not only be of value to the Government, but an important contribution to the study of adolescent growth; and, at my suggestion, annual physical examinations of the cadets at the Academy were instituted—first, that youths manifesting disqualifications for the service might be detected before they had uselessly wasted time in preparing for a career they could not pursue, thus also relieving the Government of a corresponding expense; and secondly, that something definite might be learned of the progressive rate of development of boys up to and beyond the period of maturity.

The results fulfilled my expectations. During my own term of service I tabulated over six thousand measurements, and my successors having continued them, there is now available, as the contribution of the first decade of this work, the continuous physical history of several thousand lads, beginning at the ages of admission, ranging from fourteen to eighteen, and exhibiting their growth and development for six or more successive years. Furthermore, in the instances of those who remain in the service, physical examinations of the same scope being now required preliminary to promotion from grade to grade, and recorded, the physical history of the individual is continued through his adult life, illustrating the further changes that follow the attainment of completed stature, and the influences of life at sea or of residence on certain stations. The following exemplify the character of these records, and also illustrate the difficulty of tabulating them in a condensed form, the rate of growth varying at different ages in different individuals, and according to inherited tendencies, and under diverse circum-

stances of residence, social position, subsistence, and occupation:

A. Eyes, yellow-gray; Hair, red, curly; Complexion, ruddy.

Age		Weight		Height		Chest. Mean girth.		Expansion.		Capacity.		Waist.	
yr.	mo.	lb.	kg.	in.	cm.	in.	cm.	in.	cm.	cu.in.	c.c.	in.	cm.
14	2	110	50	65	165.1	32½	80.0	3½	9.5			26½	67.2
15	8	126	57	66	169.8	34	86.0	3¾	9.5	240	3,932	26	66.0
16	11	133	60	68¼	173.3	33⅝	81.7	4¼	10.8	220	3,605	28	71.0
17	10	135	61	68½	173.3	34	86.0	4	10.0	260	4.26	29	73.6
18	10	139	63	68½	174.0	34½	88.5	4½	11.9	270	4,424	27	68.5
20	11	142	64	68½	174.0	34½	88.2	3½	8.9	240	4,752	29	73.6
Gain...		32	14	3½	8.9	2½	7.6	.	.	50	820	2½	6.4

B. Eyes, light blue; Hair, dark-brown; Complexion, fair.

Age		Weight.		Height.		Chest. Mean girth.		Expansion.		Capacity.		Waist.	
yr.	mo.	lb.	kg.	in.	cm.	in.	cm.	in.	cm.	cu.in.	c.c.	in.	cm.
15	2	91	41	60	152.0	31½	80.0	7	17.8	...	....	25	63.5
17	10	144	65	66¾	169.5	34	86.6	4½	10.8	210	3,441	29½	75.0
19	2	149	67	67½	170.8	34	86.0	2	5.0	220	3.605	29	73.6
20	1	150	68	67½	171.1	35½	90.8	3½	8.9	257	4.211	29½	75.0
21	1	144	65	67¼	172.0	35½	89.5	4½	11.4	228	3.736	27	68.5
23	2	141	64	68	172.7	35½	90.5	3½	8.2	254	4,162	29	73.6
Gain...		50	13	8	22.7	4½	10.5		..	44	721	4	10.1

C. Eyes, hazel-gray; Hair, brown; Complexion, fair.

Age.		Weight.		Height.		Chest. Mean girth.		Expansion.		Capacity.		Waist.	
yr.	mo.	lb.	kg.	in.	cm.	in.	cm.	in.	cm.	cu.in.	c.c.	in.	cm.
16	2	93	42	61½	155.5	29½	75.0	3	7.6	...	....	25	63.5
16	11	105	47	63	160.0	30½	77.0	2¾	7.0	220	3.605	25½	65.4
18	5	125	57	66¾	169.5	32½	82.0	3½	8.9	246	4.031	27	68.5
19	3	139	63	68	172.7	34½	87.2	3⅛	8.2	214	3.506	29½	75.0
19	10	136	61	68½	155.9	33½	85.7	4½	11.4	290	4,752	28	71.0
20	10	142	64	69¼	177.0	32½	85.0	4¼	10.8	305	4,998	28	71.0
21	10	147	66	70¼	179.0	34	86.0	5	12.7	320	5,244	26	66.0
23	10	151	68	70½	179.7	34½	88.2	3½	8.9	320	5,244	29	73.6
Gain...		58	26	9⅛	24.2	5¼	13.2	.	..	100	1,639	4	10.1

D. Eyes, dark gray; Hair, brown, thin; Complexion, sallow.

Age.		Weight		Height.		Chest. Mean girth.		Expansion.		Capacity.		Waist.	
yr.	mo.	lb.	kg.	in.	cm.	in.	cm.	in.	cm.	cu.in.	c.c.	in.	cm.
17	1	107	48	68	172.0	29½	74	3¾	9.5	208	3,408	23⅜	59.6
18	3	125	57	69½	176.0	31	80	3	7.6	216	5.539	26	66.0
19	3	124	56	71	180.0	31½	80	3	7.6	210	3,441	26¾	68.0
19	10	131	59	71	180.0	31	79	2¾	7.0	230	3.768	26	66.0
20	9	135	61	71	181.6	32	82	5	12.7	240	3,932	25	63.5
22	9	139	63	71¼	182.0	33	84	4	10.1	265	4,342	28	71.0
23	1	139	63	71¼	182.0	33	84	4	10.1	265	4,342	28	71.0
27	7	149	67	71¼	182.0	34	86	4	10.1	265	4,342	28½	72.0
Gain...		42	19	3¼	10.0	4	12	.		57	934	5	12.4

A system of extended physical measurements such as these, instituted in schools of all grades and for both sexes, is a desideratum in anthropology; but almost insuperable obstacles prevent its accomplishment with that precision of detail required to give it value. School-teachers are too ignorant of, or perversely indifferent to, simple sanitary requirements, and too intent upon devising novel and complex methods of pretended instruction—which under the guise of mental training dwarf the body and impair the mind—to be depended on for proper attention to human physics or physiology. The objections of parents to the inspection of even the partly nude body, also makes impossible that absolute exactness demanded for statistical purposes outside the national military, naval, and training schools, where it is obligatory. Dr. Bowditch's tables of weights include that of the clothing, varying, according to the age of the child, from two and three-fourths to nine and three-fourths pounds. Dr. Hitchcock makes a uniform allowance of three and a half pounds for clothing, and of one-seventh of an inch for thickness of stocking and slipper. The military and naval measurements are all of the nude body.

The particular physical measurements to be made are an important consideration. Dr. Hitchcock's anthropometric observations, at Amherst College, began in 1861, with the record of the age, weight, height, chest, arm, and forearm girth, and body-lift; to which were added the capacity of the lungs and, subsequently, the finger-reach, chest expansion, and comparative strength of the two hands. Dr. Sargent, at the Hemenway gymnasium at Harvard University, records both standing and sitting height, the girth of head, neck, chest, and waist, of each thigh, knee, calf, upper arm, forearm, and wrist, and the strength of the back, legs, chest, arms, and lungs. The blanks used by Dr. Hartwell, at Johns Hopkins University, embrace all these data, which are in practical agreement with the charts used by Dr. Charles Roberts, of London, described in his "Manual of Anthropometry," with height of pubis, navel, and sternum, breadth of head, neck, shoulders, waist, hips, nipples, shoulder, elbow, and elbow-tips, the length of each foot, and stretch of arms; and these are properly recorded in metric terms. Military and naval records include other items not strictly mensural, as vision, color perception, acuteness of hearing, and, for the identification of the individual, color of hair, eyes, and complexion. At the United States Naval Academy, Annapolis, Md., the form shown on the opposite page is in use.

The Anthropometric Laboratory of the International Health Exhibition at London, in 1884, arranged by Francis Galton, F.R.S., essayed to measure and record keenness of sight, color sense, judgment of eye, hearing, highest audible note, breathing power, strength of pull and squeeze, swiftness of blow, span of arms, height standing and sitting, and weight.

In my own earlier tables at the Naval Academy, which were also, for a time, extended to all recruiting stations, the vertico-perineal (properly vertico-coccygeal) height was added, in the hope that it might be a means of demonstrating that the proportionate length of the cerebro-spinal column to that of the total stature was a measure of the activity, energy, and vigor of the individual. Dr. Gould, in his investigations in the military and anthropological statistics of American soldiers, had already noticed that the "tall men did not wear as well as the shorter." Men conspicuously short often exhibit, when seated, the same body length as others who are much taller standing. I, accordingly, devised an attachment to the altitude staff for obtaining at one reading the distance from the vertex to the end of the coccyx; but experience satisfied me that very few examiners, however carefully instructed, will take this measure with that uniform preciseness which gives it any value. While some were careful to separate the nates and adjust the terminal button of the rod accurately beneath the coccyx, others merely pressed the rod against the perineum. Some negligently thrust the bar between the thighs or the closed nates; others placed it between the buttocks, but did not adjust the sliding rod that the button might impinge upon the end of the bony column, but let it strike anywhere near its termination. With every precaution, personal peculiarities of the examinee make this measurement at times difficult, as where the coccyx curves abruptly upward and inward, or is buried deeply under a thick cushion of fat.

The following instances of the measure of the same individuals at different ages, by different examiners,

PHYSICAL RECORD.

Naval cadet.....Class.....Date of birth.....

at.....Residence.....Family history (hereditary diseases, etc.).....

Color of eyes.....Hair.....Complexion.....

Permanent marks and peculiarities.....

Date of examination.	Age.		Weight.	Height.		Chest.			Waist.	Arms.	Strength.				Vision.		
						Circumference.		Capacity.			Of squeeze.				Acuteness. (Snellen's type.)		
	Yrs.	Mos.		Standing, from vertex to ground.	Sitting, from vertex to seat of chair.	Inspiration.	Expiration.	Spirometer.	Circumference.	Span from finger tips.	Right hand.	Left hand.	Of pull.	Of lift.	Right eye.	Left. eye.	Both eyes.
			lbs.	in.	in.	in.	in.	cub. in.	in.	in.	lbs.	lbs.	lbs.	lbs.	$\frac{20}{}$	$\frac{20}{}$	$\frac{20}{}$

Vision (*continued*).					Hearing.		Development.	Sickness.			
Color sense.		Judgment.						On sick or excused list, or on sick leave since last examination.			
		Error in dividing a line of 15 inches.			Distance of ticking of watch.			On shore.		At sea.	
Green.	Red.	In 2 parts.	In 3 parts.	Error in estimating squareness.	Right ear.	Left ear.		Cause.	Days.	Cause.	Days.
0–4	0–4	Per ct.	Per ct.	Degrees.	$\frac{4}{0}$	$\frac{4}{0}$					

Remarks:

when the importance of accurate observation was impressed upon them, exhibit these irregularities so markedly, that it is evident no dependence can be placed on this dimension :

Age.		Height.		Age.		Height.	
		Vertico-plantar.	Vertico-perineal			Vertico-plantar.	Vertico-perineal
Year.	Month.	Inches.	Inches.	Year.	Month.	Inches.	Inches.
16	10	67⅛	33½	17	—	72	36
17	1	68½	32¾	21	—	73	36½
17	10	69⅞	35	23	—	73	37¾

Age.		Height.		Age.		Height.	
		Vertico-plantar.	Vertico perineal			Vertico-plantar.	Vertico-perineal
Year.	Month.	Inches.	Inches.	Year.	Month.	Inches.	Inches.
17	10	69¼	34½	17	10	69¼	36
18	10	70⅜	35¼	18	10	70½	35½
19	10	71¼	34½	19	10	70½	35¾

The several thousand observations made, however, did give reason for the inference, (1) that the cerebro-spinal axis is relatively longer in the earlier years of adolescence, as shown by the following averages :

Years of age.....	14	15	16	17	18	19	20	21	22	23
Ratio of length of cerebro-spinal axis	.510	.510	.516	.512	.509	.508	.506	.505	.490	.494

and (2) that greater stature is generally due to greater length of legs, as exhibited in the following table.

There is a difference of 14 inches between the greatest and least averages of height, but the tallest youth, while having legs 9.4 inches longer than the shortest, has a cerebro-spinal axis of only 4.6 inches greater length.

Height.	Ratio of length of cerebro-spinal axis to stature.	Length of cerebro-spinal axis.	Length of inferior extremities.
Inches.		Inches.	Inches.
59 to 60	.529	31.7	28.3
60 to 61	.532	32.5	28.5
61 to 62	.516	32.0	30.0
62 to 63	.517	32.5	30.5
63 to 64	.516	33.0	31.0
64 to 65	.517	33.5	32.5
65 to 66	.517	34.0	32.0
66 to 67	.511	34.2	32.8
67 to 68	.513	34.9	33.1
68 to 69	.508	35.0	34.0
69 to 70	.504	35.2	34.8
70 to 71	.495	35.0	36.0
71 to 72	.497	35.8	36.2
72 to 73	.499	36.4	36.6
73 to 74	.491	36.3	37.7

The measure of the sitting height by means of a measuring-rod fastened upright to the back of a solid, narrow chair, as at Mr. Galton's Anthropometric Laboratory, is a clumsy procedure, giving results of no practical value, a superabundance of fat upon the buttocks sufficing to establish a considerable difference between two persons having actually the same length of cranio-vertebral column.

For statistical purposes, absolutely precise measurements are alone worth recording. Dependence cannot be had upon the rectification of errors by the neutralization of excesses and deficiencies in a large number of observations. Mistakes through carelessness or indifference, habitual with some examiners, vitiate the results of those who are accurate, and nothing requires more care than the mensuration of the flexible, mobile, human body. From the inherent difficulty in establishing fixed points on the rounded outlines of the human form, even the same examiner will often vary in the same dimension repeated on different occasions. Tailors' misfits are often attributable to this rather than to lack of skill, and women wisely have themselves fitted over artificial corset frames rather

than over their own figures. The attempt to ascertain the exact length of limbs or lesser members, or the size of regional divisions of the body, can be successful only for approximate measurements of no statistical value. More or less thickness of adipose sheathing, a rounder or sharper extremity of a bone, a greater or less curve in its shaft, the obliquity of the bony casing of a cavity, or the flaccidity of its muscular walls, may cause discrepancies when there is actual anatomical identity.

Girth measures are more easily obtained than length of limbs, but are only useful as evidences of improved muscular development after athletic exercises. The girth of the waist varies according to the place of measurement, and the uniform selection of the level of the umbilicus secures no greater precision, since its relative location has very wide limits. The girth of the chest, presumably one of the simplest measurements, is also subject to very great discrepancies, according as the circumference of the thorax is taken at rest or after moderate or forced inspiration or expiration, or as the tape-line is placed in a perfectly horizontal plane at the level of, or above or below, the nipples, or above or below the apices of the scapulæ, or whether the stout fingers of the examiner, holding the tape in position, are allowed to add their bulk to the measure.

In females, the greater or less development, or higher or lower position, of the mammæ adds to the difficulties of correct measurement.

The earliest units of measure were, undoubtedly, obtained from the human body, and these were so nearly uniform that they served the rude requirements of the time. Existing designations in all languages indicate their survival. The foot was the Herculean unit of land measure. The forearm length gave the cubit, which doubled was the ell (*ulna*, ὠλένη), while the hand was measured in its breadth for the *palmus minor*, the palm or hand of horse-dealers being the depth of four fingers (*quatuor digitos transversos*), whence the term digit for all numerical symbols; or in its length, the *palmus major*, or the span, being the distance from the end of the thumb to that of the little finger extended. The finger-reach from tip to tip of arms extended horizontally, approximately six feet, gives us through the Anglo-Saxon our fathom (*fädhem*, to embrace), and the girth of the body, from *gyrdan*, to girdle, our yard.

There was sufficient coincidence between these several units to suggest their general relation, and after a while it came to be believed that the dimensions of the body could be expressed in terms of one or the other. Dr. Robert Fletcher, in "Human Proportions in Art and Anthropometry," has gathered the literature of these attempts to discover the supposed occult relation to all the dimensions of the body of some one special part or modulus, so that, given this part, the remaining dimensions could all be educed from a geometric diagram. The Egyptian modulus is supposed to have been the length of the middle-finger, of which nineteen represented the true length of the whole body. By the Canon of Polykleitus the head, from the chin to the top of the scalp, is an eighth of the total height, the foot a seventh, the cubit and the width across the shoulders each a fourth. Professor Carus took the length of the hand for his unit. Other writers have sought to establish the determinate ratio existing between the several dimensions of the body by means of arcs and angles, and erected squares or other figures; and however pleasing to the eye the handiwork of statuaries governed by these proportions, it is the fact that they are not found among the living bodies which people the earth.

While, however, there are the widest divergencies of individuals in their several measurements, anthropometrists have found in a large number of observations an equilibrium in the departures from the means of the whole number of persons.

The following tabulation of over six thousand observations of cadets at the United States Naval Academy exhibits (1) the means of all the observations and the number of individuals per thousand near these means, and of those above and below them; and (2) the average range of normal divergence from these mean measures, with the number of individuals per thousand within this range, and of those outside its limits:

Ages.	Number of persons examined.	Weight. Mean.	Number per M. Below.	At or near.	Above.	Average range.	Number per M. Below.	Within.	Above.	Height. Mean.	Number per M. Below.	At or near.	Above.	Average range.	Number per M. Below.	Within.	Above.	Chest-girth. Mean.	Number per M. Below.	At or near.	Above.	Average range.	Number per M. Below.	Within.	Above.
years.		lbs.				lbs.				in.				in.				in.				in.			
14 to 15	269	95.9	409	264	387	70–120	29	907	64	61.0	343	123	524	57–66	89	852	59	29.0	296	189	515	26–32	50	904	46
15 to 16	586	106.4	343	268	389	80–140	50	935	15	63.9	504	111	495	59–68	77	866	57	30.0	429	211	359	27–34	43	927	30
16 to 17	1,104	116.2	387	225	388	90–150	36	948	16	65.4	447	165	388	61–70	59	904	37	31.5	413	207	380	28–35	42	933	25
17 to 18	1,424	123.0	457	247	296	100–150	54	896	50	66.4	472	159	375	62–71	40	941	19	32.3	451	224	325	29–36	30	945	25
18 to 19	753	130.1	271	260	469	110–160	77	892	31	66.9	554	179	267	63–71	45	927	28	33.1	291	247	462	30–36	24	933	43
19 to 20	736	133.3	449	251	300	110–160	47	902	51	67.3	456	168	376	63–71	33	920	47	35.4	473	197	330	30–37	14	963	23
20 to 21	598	135.7	383	249	368	110–160	28	889	83	67.4	444	175	381	63–71	37	909	54	33.8	387	203	410	31–37	50	944	46
21 to 22	372	135.3	400	261	339	110–160	30	906	64	67.4	449	188	363	64–71	59	882	59	33.9	368	192	440	31–37	40	920	40
22 to 23	147	136.9	347	272	381	110–160	14	898	88	67.6	463	136	401	64–71	61	898	48	34.0	510	218	272	31–37	48	898	54
23 to 27	125	139.0	424	192	384	110–170	48	888	64	67.8	424	192	384	64–71	16	896	88	34.3	552	104	344	31–38	40	920	40
Aggregate..	6,057	....	387	243	370	....	41	906	53	....	425	159	416	....	51	892	50	....	418	199	383	.....	38	925	37

It will be observed, from the averages on the bottom line, that among every thousand lads, while less than one-fourth will actually approach the means in weight, height, and chest-measure, there will be a nearly equal number above and below them; and further, that five percentum will represent those over, and as many more those under, a range above and below these means of about twenty-five pounds in weight, four inches in height, and three inches in chest-girth—a latitude not inconsistent with perfect health, bodily vigor, and the normal development peculiar to the type of the individual.

These results are in conformity with the mathematical law of the coefficients of the binomial, by which symmetric curves can be constructed, receding bilaterally from a perpendicular representing the mean, and diminishing regularly to the extremes, and even beyond these extremes Quetelet places dwarfs and giants, regarding them as symmetrical extensions of these curves.

In the following tables are represented the condensed results of 38,571 measurements of the human body during the period of adolescent growth, the data being obtained from

I. Professor H. P. Bowditch's investigations on the growth of children;

II. Medical Director Albert L. Gihon's report of measurements of cadets at the United States Naval Academy; and

III. Professor Edward Hitchcock's report, based upon an experience, embracing a period of twenty years, in the department of physical education at Amherst College.

The practical coincidence of these results by indepen-

I. Heights and Weights of Boston School Boys and Girls.

Ages. Years.	Number examined. Boys.	Girls.	Weights corrected for clothes. Boys. Lbs.	Kg.	Girls. Lbs.	Kg.	Heights without shoes. Boys. In.	Ctm.	Girls. In.	Ctm.
5	848	605	38.24	17.34	36.82	16.70	41.57	105 6	41 29	104.9
6	1,258	987	42.14	19.11	40.38	18.32	43.75	111.1	43.35	110.1
7	1,419	1,199	45.63	20.69	43.87	19.89	45.74	116 2	45 52	115.6
8	1,481	1,299	49.86	22.62	48.53	22.01	47.76	121.3	47.58	120.9
9	1,437	1,149	54.47	24.70	52.84	23.97	49.69	126.2	49.37	125.4
10	1,563	1,089	59.58	27.01	57.81	26.22	51.68	131.3	51.34	130 4
11	1,293	936	63.49	28.80	63.96	29.01	53.33	135.4	53.42	135.7
12	1,253	935	69.65	31.60	72.67	32.96	55.11	140.0	55.88	141.9
13	1,160	830	81.44	36.94	83.00	37 69	57.21	145.3	58 16	147.7
14	968	675	86 82	39.38	90.94	41.25	59.88	152.1	59.94	152.3
15	636	459	99 02	44.91	98.23	44.55	62.30	158.2	61 10	155.2
16	359	353	111.34	50.50	103 94	47.14	65.00	165.1	61 59	156.4
17	192	233	117.31	53.21	107.66	48.83	66.16	168.0	61.92	157.2
18	84	155	121.96	55.32	107.22	48.67	66 66	169.3	61.95	157.3
Total	13,691	10,904	.....	.....	.....	.....	.....	.....	.....	.....

II. Physical Measurements of Cadets at U. S. Naval Academy.

Ages. Years.	Weight. No. of examinations.	Lbs.	Kg.	Height. No. of examinations.	In.	Ctm.	Chest-girth. No. of examinations.	In.	Ctm.	Expansion. No. of examinations.	In.	Ctm.	Chest-capacity. No. of examinations.	Cu. in.	C.c.
13–14	29	83.5	37.87	29	58.7	149.0	27	27.8	70.6	27	2 5	6.4	3	157	2,572
14–15	269	95.9	43.50	271	61.1	155.2	260	29.0	73.9	259	2.5	6 4	27	186	3,047
15–16	586	106 4	48.25	596	63.9	162.3	560	30.3	76.9	560	2.5	6.4	107	197	3,228
16–17	1,107	116.2	52.70	1,123	65.4	166.1	1,083	31.5	80.0	1,078	2.6	6.6	319	210	3.441
17–18	1,424	123.0	55.79	1,437	66.4	168.6	1,404	32.3	82.0	1,396	2.8	7.1	542	219	3,588
18–19	753	130.1	59.01	754	66.9	169.9	749	33.1	84.0	749	3.0	7.6	481	227	3,719
19–20	736	133.3	60.46	737	67.3	170.9	727	33 4	84.8	727	3.0	7.6	459	230	3,768
20–21	538	135.7	61.55	538	67.4	171.2	522	33.8	85.8	522	3.0	7.6	301	236	3,867
21–22	372	135.3	61.27	372	67.4	171.2	370	33.9	86.1	370	3.0	7.6	206	239	3,916
22–23	147	136.9	62.10	147	67.6	171.7	147	34.0	86.3	147	3.2	8.1	111	242	3,965
23–27	125	139	63.05	125	67.8	172 2	125	34.3	87.1	125	3.5	8.8	119	244	3,998
Total	6,086	....	....	6,129	....	....	5,976	....	....	5,960	....	....	2,675	....	....

III. Physical Measurements of Students of Amherst College.

Ages. Years.	No. of examinations.	Weight, corrected for clothes. Lbs.	Kg.	Height, .15 in. deducted for shoes. In.	Ctm.	Chest-girth. In.	Ctm.	Chest-capacity. Cu. in.	C.c.
17	330	128.4	58.24	66.45	168.8	33.87	86.0	225	3,683
18	1,172	130.5	59.19	66.81	169.7	35.10	89.1	239	3,911
19	1,511	132.3	60.00	67.15	170.5	35.38	89 8	240	3,937
20	1,358	134.6	61.05	67.80	172.2	35.52	90 2	249	4.077
21	1,171	136.5	61.91	67.86	172 4	35.58	90.4	250	4,098
22	807	137.5	62.37	67.96	172.6	35.98	91.4	251	4,109
23	559	137 7	62.46	68.16	173.1	36.29	92.2	257	4,211
24	362	139.9	63.45	68.29	173 4	37.23	94 5	261	4,277
25	216	141.6	64.23	68.53	174 1	36.66	93.1	264	4,320
26	141	131.4	64 13	68.67	174.4	37.46	95.1	263	4,301
27	71	140.9	63.91	68 15	173 1	36.95	93.8	268	4,398
28	30	137.2	62.23	68.37	173 6	36.28	92.1	269	4,409
29	19	139.2	63.14	67.94	172 6	36.41	92.5	261	4,269
30	18	143.0	64.86	69.04	175.4	36.70	93.2	280	4,580
Total	7,765	.....	.....	.....	.....	.....	.....	.....	.....

dent observers is shown in the diagram on p. 672 (Fig. 2879).

Increase in height practically ceases by the twenty-third year, which may be considered the period of completion of adolescent growth. Supplementing the above statistics of youths is the summary (see p. 672) of physical observations of nearly a million and a half adult men beyond this age, examined for enlistment in the army, and, therefore, during the period of greatest bodily vigor, given in Dr. Baxter's "Medical and Anthropological Statistics," along with those of over sixteen hundred adult naval cadets and college students.

The physical measurements which are indispensable elements of anthropometric statistics are: 1, Weight; 2, height; 3, chest-girth; 4, chest-expansion; 5, chest-capacity. With these should also be noted, for the identification of the individual and as part of his physical history: name; age, color of hair, color of eyes, color of skin, visual power, color perception, and acuteness of hearing. The girth of the waist and of the limbs cannot be regarded as among such exact data as are useful for statistical purposes. The breadth of shoulders and of the pelvis, and the length of the several members of the extremities, are not capable of accurate measurement so as to give consonant results. Dynamometric estimates are similarly objectionable. The diversity of machines, their variability, the different methods of using them, and the greater or less dexterity in manipulation, produce results which are not always correct criteria of muscular power.

The weight should be that of the nude body. When the clothing is included this should always be stated, and the actual or estimated weight of clothing indicated. The body is best weighed on ordinary platform-scales. Machines have been contrived for obtaining weight and altitude together, but in the best of these (as the Buffalo

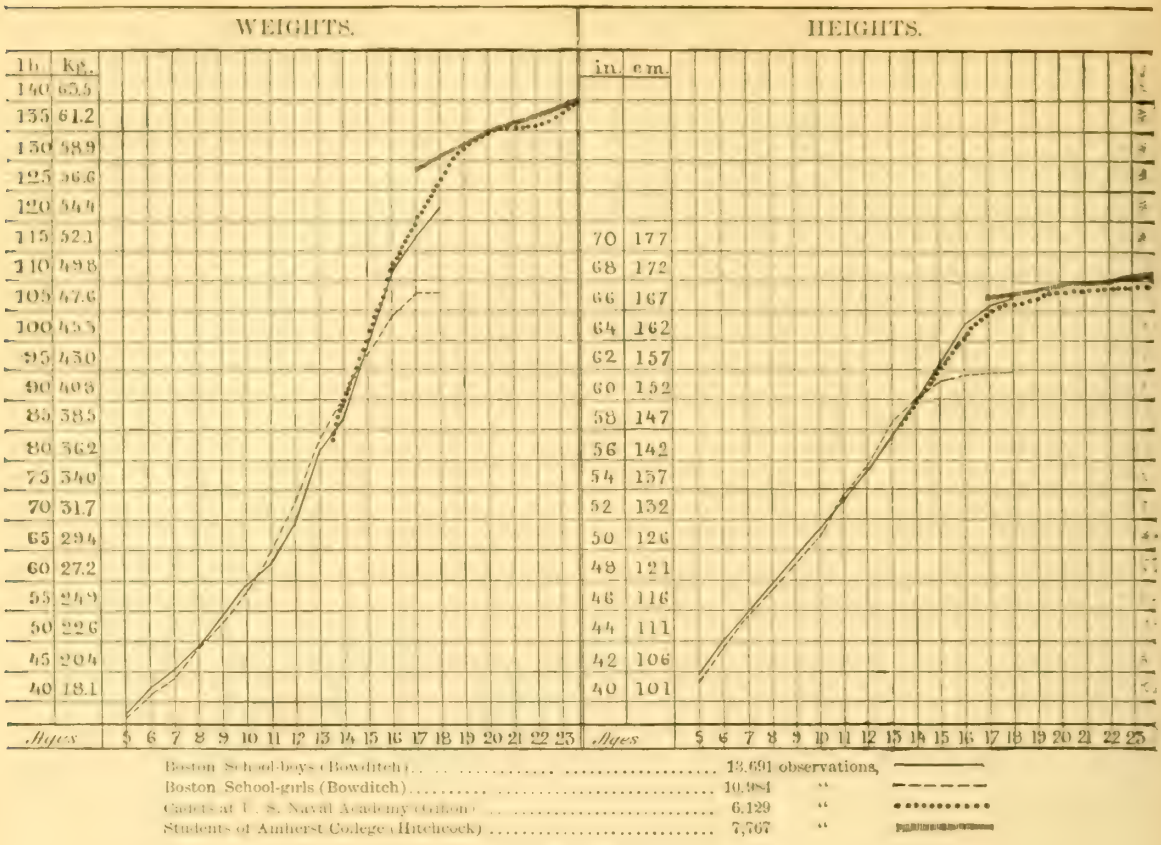
WEIGHTS.
HEIGHTS.
lb. Kg.
in. c.m.
Ages
Boston School-boys (Bowditch) ..... 13,691 observations,
Boston School-girls (Bowditch) ..... 10,984 "
Cadets at U. S. Naval Academy (Gilson) ..... 6,129 "
Students of Amherst College (Hitchcock) ..... 7,767 "

FIG. 2879.

Company's and Casella's), the small gain of time and saving of trouble do not compensate for loss of accuracy through the necessarily imperfect adjustment of the two scales.

The measurement of height is considered so simple an operation that proper attention is seldom given to its details. A bending of the knees, the spreading apart of the feet, drooping of one or the other shoulder, the inclination of the head, neglect to hold the body square and erect, greater or less thickness of hair, are so many elements of error. To obtain absolute accuracy by putting the body of the examinee in a state of complete passivity, it has been proposed to measure the individual extended supine upon a perfectly level, unyielding surface, the vertex touching a fixed upright, with a broad foot-piece moving at right angles to meet the perpendicular soles. Machines of this sort have been devised with lateral uprights for ascertaining the distance between the acromia, iliac crests, etc., but they are of no practical value, and are necessarily complex.

Height can be satisfactorily measured upon a rigid upright by a vertex-bar moving without play at right angles to the upright. The neglect to observe this precaution allows the end of the bar to traverse an arc of an inch or more, increasing or decreasing the true height to this extent according as it is elevated or depressed from the perfect level.

Fig. 2880 represents the altitude staff made from a design prepared by me for the use of medical examiners in the Navy during my service as Inspector of Recruiting. The points on the vertex-bar are intended to be pushed through the hair until they touch the scalp, the index-point reading at this level. The perineal bar shown was devised to measure the vertico-perineal or vertico-

Persons examined.	Number of examinations.	Average ages.	Weight.		Height.		Chest-girth.	
		Years.	Lbs.	Kg.	In.	Ctm.	In.	Ctm.
Cadets, U. S. Naval Academy (Gilson)	272	24.01	137.86	62.53	67.69	171.93	34.14	86.71
Students, Amherst College (Hitchcock)	1,416	24.18	138.90	63.00	68.31	173.50	36.74	93.32
Soldiers (Hunt)	1,700	23.94	147.50	66.90	67.35	171.06	34.99	88.87
Recruits (Coolidge)	1,537	24.01	148.29	67.26	67.36	171.09	.....	.....
Soldiers (Gould)	833,260	24.09	.....	.....	67.90	172.46	.....	.....
Sailors, volunteers (Gould)	8,349	25.62	144.83	65.69	67.34	171.04	34.46	87.45
Soldiers, volunteers (Gould)	12,951	.....	142.80	64.77	67.22	170.73	35.09	90.65
Recruits, accepted (Baxter)	6,359	26.39	136.05	61.71	67.39	170.94	34.11	86.64
Recruits, accepted (Baxter)	196,980	26.96	.....	.....	67.35	171.06	35.25	89.53
Recruits, accepted and rejected, New England (Baxter)	29,930	.....	.....	.....	67.41	171.22	34.77	88.21
Recruits, accepted and rejected (Baxter)	315,620	.....	.....	.....	67.67	171.88	34.09	86.36
Recruits, accepted and rejected, Ohio and Indiana (Baxter)	77,665	.....	.....	.....	67.93	172.54	34.56	87.63
Average height of 1,486,039 adults					67.75	172.08		
Average chest-girth of 651,242 adults							34.52	87.68
Average weight of 32,584 adults			142.30	64.55				

coccygeal length on an independent scale; it is attached to the sheath-support of the vertex-bar, travelling with it up and down the staff, to obviate the necessity for obtaining the perineo-plantar measure, and subtracting that from the total height. In the haste and confusion attending a large number of examinations, and from the similarity of the numbers, this arithmetical process was often omitted and the length of the legs recorded as the true length of the cerebro-spinal column. For reasons already stated, this measure is no longer considered of statistical value. If the body is weighed nude, the height should be immediately obtained in the same condition; otherwise this measurement should be made barefoot.

A graduated tape or thin metal band is the best stethometer for measuring the chest-girth. It should be passed around the chest horizontally, immediately above and excluding the nipple, and be held there while the chest is inflated and emptied by several prolonged acts of inspiration and expiration, the mean of the two extremes being recorded, and their difference entered in another column as chest-expansion. The examiner who patiently instructs the person under examination how to do this, encouraging him to several efforts, will arrive at wider extremes than one who pursues a negligent routine method, though the means will be practically the same, on which account the single dimension has the advantage for purposes of statistical comparison.

Vital capacity of the chest, Dr. Hutchinson's term for the measure of the quantity of air capable of being voluntarily expired, is best ascertained by the spirometer bearing his name, which is simply a counterpoised vessel suspended over water. The accuracy of the results obtained is evidenced by the remarkable correspondence between Dr. Hutchinson's estimates of normal vital capacity and the means of two thousand six hundred and seventy-five observations of cadets at the United States Naval Academy. Dry expirometers have not been found to give equally satisfactory results.

Albert L. Gihon.

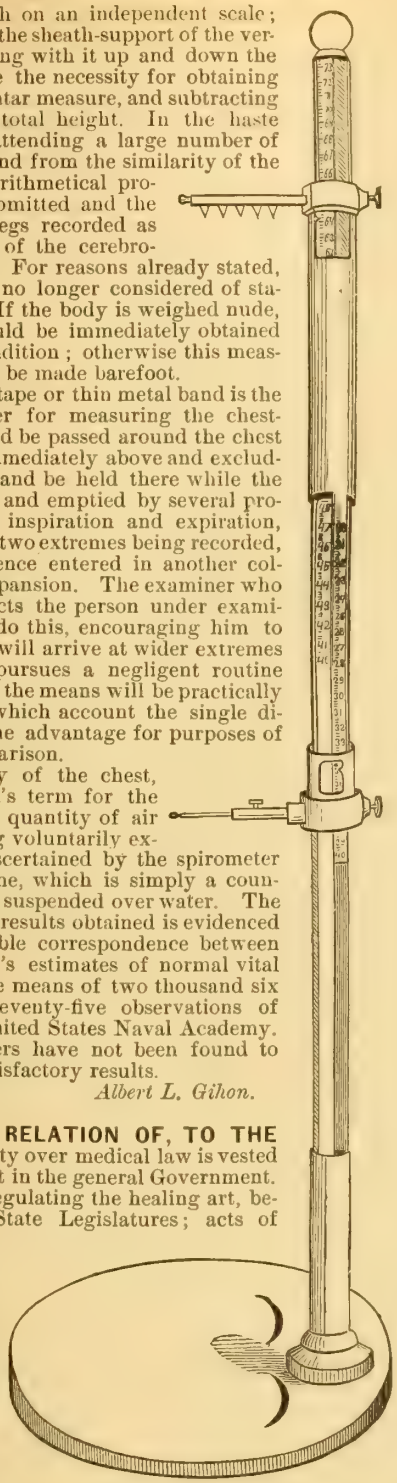

Fig. 2880.—Altitude Staff.

PHYSICIAN, RELATION OF, TO THE LAW. Authority over medical law is vested in the States, not in the general Government. To pass laws regulating the healing art, belongs to the State Legislatures; acts of Congress have very little to do with the subject. Hence various branches are regulated by statute law differently in different parts of the country. Throughout this work, the articles which depend upon statute law, give convenient summaries, as comprehensive as is consistent with the necessary brevity, of the statutes which exist in the various States. Thus the criminal penalties upon producing "abortion;" the regulations imposed on the business of an "apothecary;" the duties of physicians or surgeons under "burial laws;" their privileges in respect to "copyrights" and "patents;" the permission and restriction as to "dissection;" and as to giving "evidence" in courts of justice, especially when "expert testimony" is demanded; their right to collect "fees" by suit at law; their duties under various "health laws," "insanity laws," and "pension laws;" their liability to damages or punishment for "malpractice;" their course in regard to "post-mortem examinations" and "vivisection;" and similar topics; are discussed, as far as any general view of statutes is involved, under the appropriate titles throughout the work, rather than gathered here. The purpose of this article is to delineate in a general way, and without pausing to indicate local rules and variations, the substance of the principles to be found in the numerous decisions which the courts have rendered, founded, not upon statute, but on common sense and usage. Among them are some contradictions and more obscurities, for all judges are not gifted with common sense in equal degree, and the usages of physicians and patients North and South, East and West, are not altogether the same. Moreover, the judges do not know and apply the past decisions of the courts precisely alike, any more than all physicians know and use the same prescriptions. There is, however, a strong disposition among the courts of the various States to decide any question between doctor and patient substantially as the same question has been decided in other States, unless some local statute or usage or some very strong reasons prevent. Thus it is not impossible to gather many legal principles which are of general, though not of universal, application.

License to Practise.—In any State where there are no statutes prescribing a license to practise medicine, the probable doctrine is, that any person may lawfully offer to render services in the treatment of diseases or wounds; that no special apprenticeship is exacted; and that the practitioner, if he possesses and exercises the skill to which he pretends, and if the circumstances warrant the understanding that there was an agreement to pay for his attendance, can recover the promised fee, or such compensation as may be reasonable. Such is the position of the law in about twelve of the States. In most of the others there are laws, more or less precise and satisfactory, requiring every practitioner to pass an examination and procure a diploma, or to obtain a license to practise from some medical college or society, or from some board authorized by the State. Without this he has no legal standing to sue for fees for medical services rendered, and may even expose himself to a penalty by practising as a physician. Thus in New York State, after an era of free trade in physic which prevailed for about thirty years, laws were passed, in 1874 and 1880, under which any person who assumes to practise medicine or surgery must, under penalty, be twenty-one years of age, and must hold a diploma from a chartered school of medicine, or a license from the regents of the State University, etc.; and must be duly registered in the county clerk's office of his county. The various forms of nursing, such as "massage," are not within such regulations.

Different Schools.—The fact is well understood in law that there are different schools of medicine, but in most of the States the law aims at maintaining impartiality, and does not specially indorse any school to the prejudice of others. The general doctrine is that a practitioner, assuming him to have qualified according to law, is understood to be called to treat a patient according to the tenets of the school the practitioner espouses. His right and duty are to treat the patient according to the methods in which he has been trained and which he professes. In an Iowa case, a botanic physician recovered fees from a husband for his treatment of a wife who died, notwithstanding numerous allopathic physicians gave testimony that the treatment was injudicious. The principle is the same under various other aspects of the question which may arise. A claim for damages for malpractice cannot be maintained against a practitioner who has faithfully followed the rules of his school, however unsound the rules might be. In one lawsuit, the contract between an impresario and a vocalist was that the former should have the right of selecting a "doctor,"

whose certificate should be necessary whenever a member of the troupe asked to be excused from singing on the ground of illness. He afterward appointed a homœopathist. One of the troupe refused to consult this physician, but when he sued for his salary, the court said he was wrong; that physicians of all systems of practice have come to be recognized equally as "doctors" before the law, and the manager had the right, since the contract did not name either school, to select the one in which he had most confidence. In short, the general doctrine is, that each State makes the regulations deemed judicious (not always practically adequate), confiding the authority for giving a license to practise to representative bodies of the various schools; and that practitioners duly licensed in the several schools thus recognized by law stand on equal terms, as far as rights and obligations toward patients are concerned.

Business Name. Codes of medical ethics, the general usage of physicians in the same region of country, and the common expectations of society, govern the course of physicians in practice much more than do any specific rules of law. In the eye of the law, the doctor's position differs little from that of an ordinary individual; he is entitled to recover from one who has employed him whatever such person agreed to pay; he must pay damages if he has done injury by negligence or want of skill; and he is liable to punishment for offences, and of these a few are somewhat peculiar to his vocation. But the general principles which apply to him would be applied to any other person under like circumstances. For example, it would be very unusual for a physician to carry on business under a fictitious name; but the reasons which restrain him are professional, not legal; he has the same legal freedom as an actor. There was once a firm formed in New York City under the name of Allison & Hearn, to manufacture and sell a patent medicine, and this firm carried on a prosperous business for many years. Meantime a Dr. McAllister was in practice in Brooklyn. When he died, it was found that "Allison" and "McAllister" were the same man. The question then arose whether the post-office authorities were bound to deliver the "Allison" letters to his former partner, Hearn. The decision was that using a fictitious name is not unlawful, where no fraud is involved. This doctor's use of two names was lawful, and the letters must be delivered. Similarly, in respect to almost all questions of ordinary business conduct, the physician has the liberty of a non-professional man.

Partnerships.—There are some peculiarities characteristic of a partnership between practitioners, but they arise from the very limited nature of the business. If the purpose is the sale of drugs, the relation involves the ordinary risks and liabilities of a commercial partnership; the partners usually own the stock and fixtures, divide the profits, and share the losses. But the application of these principles to what is called a partnership between two physicians or a physician and a surgeon, is very limited. If their agreement is to divide their fees, they are bound to make their division as agreed; but the nature of the business does not warrant one partner in making contracts which can impose any important liability upon the other; nor would any lawyer think of advising a patient suffering from consequences of a surgeon's negligence, that he could maintain an action for damages against his partner. There have been a few instances in which partnerships have been formed to allow an unlicensed person to share in the practice of one properly qualified, in evasion of the local laws requiring certificates, etc. These being excepted, the lawsuits which have been brought upon medical partnerships indicate that the relation has involved simply a friendly co-operation, intended to relieve the labors of the older practitioner; a consent to some division of fees, and perhaps an engagement to share office expenses, but has not involved any legal liabilities or consequences of importance.

Who should Pay the Doctor?—If physicians' charges were less considerate and lenient than they are, courts would be vexed with various forms of the question, Who must pay the doctor? No occurrence is more common than that a person is suddenly taken ill, and any one at hand—a relative, a friend, a neighbor—goes for a doctor, leaves a message in his own name, perhaps leaves his own card, saying, call upon Mr. Blank, at such a place. If the doctor goes and treats the case, why cannot he send his bill to the man who left the order for him to come? The courts have differed on this question. One view taken has been, that whoever makes his own request, leaves his own card or message, writes his own letter bespeaking a physician's or surgeon's services, although for another person, makes himself chargeable in law for the services, when rendered. He makes the request or gives the order on which the physician goes, and, if he is not prudent enough to explain that he comes as messenger only, and to disavow any personal liability, how is the physician to know, so the argument runs, his actual intention? But there are decisions rather more numerous and weighty in favor of the adverse view, that a mere messenger does not make himself liable. In South Carolina, in the days of slavery, a "plantation physician" found a case among the slaves under his charge rather beyond his skill, and sent for a neighboring surgeon. The surgeon treated the case, and sued the plantation doctor for his fees. But the court decided against him, saying there is no understanding that everyone who merely summons a doctor engages to pay him. In Pennsylvania, there was a young man who became of age, so that his father was no longer responsible for his expenses, but who continued to live in his father's house. Being ill there, his father went for a physician. The consequence was a lawsuit against the father for the physician's charges. But the decision was, that the suit should have been against the son, who was the person benefited and was of age to pay his own bills, not against the father, who was a mere messenger. And upon the whole, the rule best supported by authority is, that there must be something more than carrying a request in order to render a person liable for the doctor's bill; the messenger should also be liable for the patient's expenses in the character of father or husband, or should make a personal promise to pay. For, whenever one person distinctly promises to pay the doctor, and the latter performs the services on the faith of that promise, the courts will enforce such promise even though not in writing. In one suit the patient was a lad who ran away from home, but returned to his father's house, where he was taken ill and died. The father employed a physician, who brought suit against him. The father argued that he was not liable as a mere messenger, and that his liability for the boy's expenses terminated when the boy ran away from home. Perhaps it did, said the court, but if so, it revived when he returned and was taken back. Claims for services to married women have generally been decided according as the wife was rightfully away from home, or had deserted her husband. In the first class of cases the husband has usually been considered the person liable; in the second class the rule is otherwise. The mere accidental circumstance who went for the doctor has not been deemed the essential fact. Cases have arisen, and these show how doubtful and perplexing the question for the physician often is, where a railroad passenger or a train-hand has been injured by some fault of the company, and some agent of the company has sent for the doctor, but afterward the company has refused to pay the bill. The courts say that the bill cannot be rendered to the company unless the particular agent who sent for the practitioner had authority from the company to do so. The general manager, in England, of a railroad company, and the "general superintendent" in some of the States in this country (not in all), have this authority. As to ordinary station agents or conductors, the courts will not take for granted that they had leave to employ a physician or surgeon. A physician who comes upon the call of any such subordinate officer may be required to prove that the latter had the requisite authority, before the bill can be collected from the company.

Importance of the Patient's Consent.—In some aspects of medical, and still more of surgical, practice, it may be important that the practitioner should be legally assured of the patient's consent. The term "assault," in law, includes any use of force or violence upon the person of another against his consent. No matter how slight or harmless the violence used may be, there is a technical assault, unless there is some special justification, which in medical practice is usually, in the case of a sane grown person, the consent of the patient, and in the case of a child, the consent of its parent or guardian. *Volenti non fit injuria*, "to a consenting person no injustice is done," is a familiar maxim, the exposition of which is, that a patient who has consented to the treatment, with a fair knowledge of the facts, cannot afterward complain of it. Many lawsuits might be mentioned which have involved these rules, but an instance which falls so near the dividing line that it illustrates both the necessity of consent, and also shows how little consent will suffice, occurred in England not many years ago. A lady became suspicious that a housemaid in her employ had become pregnant, taxed her with it, and gave her notice of dismissal. She denied it. The lady sent for her family physician, and ordered the girl to go to her room and submit to an examination. The girl protested, but went to the room followed by the physician. She objected to being examined, and objected to each of the doctor's requirements, as to removing her clothing, etc. However, she obeyed, remonstrating all the while, and the usual examination was made, resulting in the doctor being satisfied that the charge was groundless. But the mistress dismissed her, notwithstanding. A lawsuit was brought on behalf of the girl against the physician, for damages for assault. The case was several times discussed in court, with final result in the physician's favor. The courts considered that although the girl remonstrated, yet as she went to her room, undressed, and lay down to be examined, all without being forced, the examination did not take place in a legal sense without her consent. It was a case of reluctant obedience to an arbitrary, wrongful command, as distinguished from a forcible compulsion which she was powerless to resist. Perhaps she submitted through ignorance of her rights; but it was impossible to say, so the judge thought, that she did not submit, or that she was compelled to submit by force, or threat, or fear of force. It is not necessary to speak at length of the principle that a patient who is induced by falsehood or fraud to yield to treatment does not in a legal view "consent" to it. Consent given under ignorance has in some cases been held binding. Consent procured by deception is a nullity.

Doctor's Authority in Emergencies.—In view of the special knowledge and known public spirit of physicians, the law sustains them in some acts, not very definitely defined, which they find to be necessary for the saving of life or the protection of the public safety in sudden emergencies. At a time when small-pox was prevalent in a town, a physician, who was attending several patients in one house, observed that the wall-paper in the sick-rooms had become infected, and might propagate the contagion. He caused the paper to be scraped off. The landlord of the building sued him for trespass. But the court said that the doctor's act was not a trespass, but was justified by the circumstances. Such a decision implies that there must be some authority in physicians to do what they find in the course of their practice to be absolutely necessary for immediate protection of human life and safety.

Confidential Character of the Relation.—There are many other respects in which the relation of physician and patient is treated in law as highly confidential. In Michigan, a physician summoned to attend a confinement asked a young unmarried man, who was not a practitioner or student, to accompany him; and this young man went, and took a very slight part in assisting the doctor. There were many circumstances tending to make his so doing excusable, such as a dark, stormy night, roads impassable to horses, instruments to be carried, physician greatly fatigued, house containing one room in which the patient lay and no other where the companion could wait, etc. Both the woman and her husband consented that the volunteer might enter the sick-room; but neither she nor the husband knew, when they assented, that the volunteer was not a medical man; and on this ground both the accoucheur and his companion were strongly censured by the court and mulcted in damages. Another class of cases illustrating the confidential character of the relation are those in which bargains, gifts, deeds, legacies, and other transactions between the parties have been set aside by the courts, when they took place under such circumstances as to give ground to think that the physician might have exerted a personal influence derived from the relation in obtaining them. It is not too much to say that courts do not exact, from persons complaining of such transactions, any explicit proof that the physician involved did actually abuse his patient's confidence. They are more apt to require proof from the physician that he did not; to assume that the relation gives so many opportunities for obtaining an influence and using it improperly, as make it unsafe to allow transactions in which a professional man may have obtained an undue advantage. The extent and limits of the duty of preserving secrecy about the patient's disclosures have been briefly treated elsewhere in so far as statute law in this country prescribes them. Brouardel, in his essay entitled "Medical Secrets," published in the "Nouveau Dictionnaire de Médecine et de Chirurgie," discusses the ethics of this subject ably. He gives a brief history of the question, presents the views of celebrated contemporaneous French writers, and quotes provisions of the codes which impose damages, fine, and imprisonment on members of various branches of the medical profession, including health officers, who disclose professional secrets excepting where the law compels them to do so. The doctrine is more distinctly and definitely expressed in the French law than has been usual in this country, and the essay is well worthy the attention of anyone interested in procuring improvements in legislation on the subject. The practical difficulty in framing such laws has been to distinguish between cases in which it is desirable to protect the reputation or other interests of the patient against injury to him from wanton disclosures of his confidential revelations to his physician, from cases in which interests of third persons, or the demands of the criminal law, require a disclosure to be made. The general view has been that a law which in general terms forbids physicians to make such disclosures is subject to restrictions, which common sense and public policy impose, allowing the disclosures to be made in necessary cases. Two New York instances illustrate by contrast the proper administration of such a statute. In one case Pierson had been indicted for the murder of Withey by poison. While Withey lay sick from the effects of the drug which Pierson was suspected of having given, a physician was called to treat him. On the trial of Pierson this physician was called as a witness, and the district attorney asked him to state what he saw and heard as to his patient's condition during the treatment. The counsel for the accused objected, but the doctor was allowed to answer, and he described the symptoms of poisoning by arsenic. The Court of Appeals pronounced the course correct, saying that the statute must be understood in a sensible way, and administered according to the undoubted intention, which is to protect the patient and the physician in legitimate communications, not to shield criminals. The purpose clearly is to enable a patient to make known his condition to his physician without the danger of any disclosure by the latter which would annoy the feelings, injure the character, or impair the standing of the patient while living, or disgrace his memory when dead. Because the statute is expressed, in unqualified terms, it does not follow that it must be administered absolutely, without limit. To invoke it for the purpose of shielding one who is charged with murder, by suppressing the most natural and trustworthy testimony as to the injuries known to have been sustained by the victim, would be a gross perversion. The case to be contrasted with this differs from it in this fact, not unimportant, that the professional visit

in the Pierson case was made to the victim, while in the Stout case, now to be mentioned it was made to the suspected criminal. Early one winter morning the corpse of Littles was found in the Genesee River just below the Falls. Examination of the spot gave reason to believe that Littles had been murdered during the night preceding, in a struggle of some violence taking place on the summit of a high bank; that his body had been thrown over the bank, and below had been dragged to the river; and that in the affair his assailants had fallen over the bank in a way to receive serious injury. During the forenoon of the same day Stout was found in the neighborhood, wearing one arm in a sling, and bearing severe scratches and contusions on his face. These injuries, of which he gave no satisfactory explanation, excited suspicion, the more so that the face of his sister, who was the wife of Littles, showed similar bruises. He was taken to jail. Next morning his hurts were seen to need treatment, and physicians were called to see him. Their purpose seems to have been partly to treat him as a patient, partly to make comparison of his condition with the facts that were steadily coming to light relative to his sister's injuries and with the circumstances of the mysterious murder then exciting the neighborhood. When at length Stout was brought to trial for the murder of Littles, one of these physicians was allowed to state what he observed and had been informed as to the prisoner's condition on the morning of his professional visit. Stout's counsel, of course, objected, and the objection was sustained. Apparently, no great attention was bestowed on the question whether the fact that suspicion of crime is involved warrants making an exception to the statutory prohibition. The judge said that he considered the purpose of the law to be to give to the relation of physician (or surgeon) and patient the same privilege as has been from early times accorded to that of attorney and client; and this, as everyone knows, extends to admissions of guilt.

What effect may be attributed to the death of the patient? An earlier view was that the privilege was personal to him, so that, after his death, no one else could assert it. A will was contested, in 1850, before Surrogate Bradford, on the ground of mental capacity of the testator; the physician who was in attendance upon the testator about the time when the will was made, was questioned, as a witness, as to what he learned of the patient's condition during his professional attendance. And the surrogate allowed the questions to be put; for he said that, the man being dead, there was no one to claim the statutory privilege as matter of right, the court might require the physician to disclose all that seemed to be proper under the circumstances. Contrast with this the more recent decision in Grattan's case. The story of the case was that Grattan applied to a Life Insurance Company for a policy upon his life. One of the usual printed inquiries required the applicant to disclose the nature of his deceased mother's last sickness. The answer written in the blank was: "Intermittent fever after childbirth." But, after Grattan's death, the company received information that the mother's last illness was, in fact, consumption. For this misstatement, they contested the policy, and they proposed to prove their case by the testimony of the physician who attended the mother. The New York Court of Appeals decided that this could not be allowed. The statute operates between the physician and his patient whenever the relation exists, and its object is to compel secrecy as to any information acquired by the physician in attending his patient, and which he needed while acting in that capacity. It embraces what the physician learns by observation, as well as what he is told; the results of a physical examination to which the patient submits in view of his need of advice or treatment, are equally protected with his oral disclosures. Nor is there good ground to say that the death of the patient severs the relation in such sense as to release the privilege. The seal of confidence must remain until removed by the patient. In this respect, the statutory prohibition "no physician, etc., shall disclose," must be taken in its fullest sense. The physician must not tell what he learned, not because the patient declared the communication to be confidential, or because the physician considered it so, but because the statute says that the communication shall not be by him disclosed. The result is that the privilege is fully and firmly established for the protection of the feelings and the interests of the patient, not only while living, but forever, unless voluntarily released by him; but that it is not available for third persons as a shield against inquiries by the criminal law. Whether it may be used to shield the patient from paying the doctor's bill is a question which was put some years ago, and the Court said: "No." No reason is perceived as yet for departing from this view.

Slander.—The law as to libel is substantially this: That any aspersive, ridiculous, or defamatory matter, whatever it may be, which is falsely and maliciously published in writing or print, is actionable as libellous. This principle evidently applies to physicians and non-professional persons equally, and does not need any special explanation here. The rule as to slander is different. Aspersive or ridiculing words are not actionable if merely oral, unless they charge a crime, or impute a contagious disease, or defame the person in respect of his skill or honesty in his profession or trade, or actually cause him some special pecuniary damage. That part of the rule which relates to injurious words spoken of a person in respect to his profession has, of course, a close application to physicians, surgeons, and other persons connected with the various branches of practice; and many lawsuits have arisen upon the question, what spoken words are regarded as legally injurious. Odgers ("Dig. Lib. and Slander," 75), defines the rule to be: "Any words imputing to a practising medical man misconduct or incapacity in the discharge of his professional duties are actionable." He gives the following as examples: To accuse a practitioner of having caused the death of a patient by ignorance or culpable negligence; to call a physician by such opprobrious names as "quack," "empiric," "mountebank," or the like; and about thirty years ago a regular physician was cast in damages for calling a homœopathist a quack. But this latter decision was rendered on the ground that lawfully qualified or licensed practitioners are entitled to respect as such, whatever their schools; for in a case in which the practitioner called quack, ought by law to have been formally qualified, but was not, the court refused to entertain his complaint, saying that the law protected only lawful employments. In instances where a physician has been charged with seduction, adultery, or the like, the question has been whether the woman involved was his patient or not; for if such a charge is so phrased as to import that the professional confidence was used to induce or to deceive her, it imports misconduct in the professional character; otherwise, where she is a stranger. Moreover, it is well understood that if the aspersive remarks were true, or if, though erroneous, they were uttered in good faith, and in answer to inquiries by a person who had an interest in knowing the physician's character, a lawsuit for them cannot be maintained.

Wills.—There are peculiar and obvious reasons why a physician should have some general knowledge of the law of wills, and should be and feel qualified to draw one. There is no legal objection or obstacle to his doing so. Of all instruments known to the law, a will is the one in which the least of formality or technical accuracy is required. Wills have been sustained which were scarcely half a dozen lines in length, which were illiterate to a degree, which were obscure and ambiguous beyond what would be allowed in a contract, or even in a business letter of a sort to be enforced as a contract. The law does not require that the draftsman of a will shall be a lawyer, or even a skilled writer. Any person may draw a will, his own or that of another. Whoever is qualified to write an intelligible letter of directions about ordinary business, has literary and legal skill enough for the drawing of a will, after he has learned one or two simple rules about the formalities of execution.

Two sorts of wills may be mentioned as proper exceptions to the suggestion that physicians may wisely un-

dertake to draw them. One class embraces those wills in which the testator is not willing to make simple gifts of property, but desires to "tie it up," as the common expression is; to create difficult and complex trusts; to leave money to a daughter so that her husband cannot interfere with it, or to a society so that the managers cannot change the use of it, or to trustees to accumulate it for some remote use. There are many rules of law which limit the power to settle property for such purposes, and when a physician, asked to aid about a will, finds that such is the intention, he will do wisely to advise sending for some lawyer acquainted with the subject. The other class includes wills which give legacies to the physician himself. As has been already explained, the law is jealous of all dealings or gifts between physician and patient, in which the doctor may perhaps have used his personal influence for his own advantage; and when a gift to himself is to be made the physician had better leave the drawing of the will to some third person.

Supposing the case to be one in which the attending physician may properly draft the will, he should be careful that the paper shows in its terms that a will is intended. In a number of cases the courts have found it rather difficult to determine whether the paper submitted to them was meant for a will, or was merely a deed, a memorandum, a credit in accounts, or the like. A form of heading, which has become very common in modern times, is: "The Will of A. B.;" and this is entirely sufficient. A form which was once very popular, and is still used, runs thus: "In the name of God, Amen. I, A. B., being of sound health (*or* being sick and weak), but mindful of the uncertainty of life, do make this my last will and testament." Either of these headings, or any title which indicates clearly that the paper is the will of the individual who signs it, is sufficient.

No advice need be given to the doctor as to the mode of expressing the bequests, except that he should state the patient's wishes simply and literally, and that he will do wisely to forbear making any suggestions or giving advice as to how the property shall be disposed of. If the true meaning and actual intention of the instrument can be determined from the language employed, the will is properly drawn. Efforts, however well meant, to influence the patient's mind as to the manner of disposing of the property, are very apt to lead to misunderstandings and lawsuits.

After the bequests have been written, there remains the duty of attending to signing and witnessing, and these are matters of prime importance. The laws of the States differ somewhat, and the law which should be obeyed in any given case is, if the law relates to personal property, that of the State where the testator has his home at the time of his death; if to real property, that of the State where the property lies. Thus, a physician called to attend a person taken sick on a journey should take care that the signing and witnessing follow the law of the patient's own State. Massachusetts allows a will made out of the State, and valid by the laws of the place where it was made, to have the same effect as if it had been made according to Massachusetts law; but this is not a general rule. The will should follow the law of the testator's residence. In regard to lands, the rule is, and is quite universally applied to other things than wills, that the law of the State where the land lies governs; but it is not difficult to conduct the signing and witnessing of a will in such a manner that the instrument will be valid under the law of almost every State. The system in Louisiana is peculiar and complex: that State, also the Territories, may well be omitted from this brief statement. Massachusetts requires three witnesses; so, unless the laws have been recently relaxed, do Connecticut, the District of Columbia, Florida (when real estate is involved), Georgia, Maine, Maryland, New Hampshire, South Carolina, Vermont. In other States, two witnesses are enough. Several States allow a will written by the testator's own hand—olographic wills these are called—to be proved, though it be not signed by attesting witnesses. Usually there is no difficulty in obtaining three persons, and so doing avoids all question as to the proper number. The witnesses should be of sufficient age and mental ability to understand what is done, remember it distinctly, and give a straightforward account of it in court; and in order to avoid any possible objections, they should be persons who will not have any interest in the estate as legatees if the will is proved, or as heirs if it is not. They need not know the dispositions or gifts made by the will; that they know it is a will and is signed as such, is sufficient. The witnesses must meet the testator for the purpose of completing the instrument. Let him sign his name, which should be written at the end of the bequests and directions. If he cannot write, let him make his mark—the sign of the cross. In most of the States, another person may write the testator's name for him, in his presence and by his express direction. Let him then tell the witnesses that the paper is his will, and that he wishes them to witness it. The manner in which he does this is not important, so that the idea is distinctly conveyed. It is not unusual for someone to ask him, "Is this your will, and do you wish these persons to witness it?" and for him to answer "Yes." Something must be said and done, the more explicit the better, to evince the testator's wish that the paper should be attested as his will. The witnesses (except perhaps in Pennsylvania) must then sign their names. There is a custom which is very advantageous, though not absolutely necessary to the validity of the will, to place these names under a brief memorandum, such as this: "Subscribed (or acknowledged) by the testator in our presence, and declared by him, to us, to be his will, whereupon we, at his request, signed our names as witnesses, this day of ——, 18—." Witnesses may make marks if they cannot write. The addition of their residences to their signatures is convenient, and in New York the omission so to do exposes the witness to a penalty. These directions are more stringent than are necessary in many States; they are sufficient almost everywhere.

Benjamin Vaughan Abbott.

PHYSIOGNOMY, MEDICAL. At the mention of the physiognomy of disease, one is apt to be surrounded by a sense of luminous expectation, out of which is evolved a series of more or less picturesque images of the special instances of physical and mental suffering with which he is familiar. This is purely an individual achievement, and depends on the acuteness of the visualizing faculty which is present, either as an endowment or as the result of training. If we go further, it is found that the personal expression of these mental pictures gradually disappears, and that we have as a background an abstract, or better, a cumulative idea of the type of disease from which the individual suffered. This is in effect the mental analogue of the composite portraiture of Galton. There can be no doubt either as to the existence of these perceptions, or as to the instinctive use of them in practice; but the question is, how far can they be formulated and trusted; have they a lineage which we may fairly recognize, or are they of such stuff as the poet describes upon an hereditary face as "dreams of tradition?"

Most of the modern writers upon diagnosis do not speak hopefully in this matter of exact treatment, and while confessing the value of the method to trained observation, are for the most part content with the current rules for the inspection of the patient, and the mention of various paralyses, atrophies, local vascularities, and pigmentations, or brief allusions to emotional disturbances of the face. The importance which the ancient writers and workers in medicine gave to this branch of semeiology, prosoposcopy, or inspection of the person, is well known; and it is probable that even the existing accounts are an inadequate expression of their practical acuteness in observation. Within the limits of their pathology, and without instruments of precision, the aspect of the patient was of paramount interest, and it was a large part of their medical divination to learn

"to trace
The day's disasters from his morning face."

It is the first, natural, and instinctive method, and it is not to the credit of our later wisdom that such an obvious means should be neglected or discouraged, although it may not readily submit itself to the modern craving for rule and definition.

Laycock, whose insight in physiognomical diagnosis is said by Hutchinson to have "amounted almost to genius," has given us by far the most graphic, acute, and thorough schematic treatment of the subject, as certainly the greatest latitude to the definition of medical physiognomy. He affirms that "in the practice of medicine the physiognomy of a patient includes every cognizable characteristic: his temperament, form of head and face, features, muscular firmness, complexion, expression, attitudes, gestures, tone of voice, manner of speaking, style of handwriting, and the like." This is a large meaning, and will be seen to demand much. Moreover, it is not an appeal to the imagination, but to minute study and the many checks of experience. The limits of this definition are wide, but they are not loose, although they embrace the most liberal collateral knowledge of race, sex, age, and occupation. Such affirmation of knowledge, however, will be found necessary in order to correct a hasty generalization, it may be as to diathesis, or some assumption or deduction from temperament—the latter of which, no matter how strong the original stream may be considered, must be held easy of deflection and disturbance by nationality and environment, and the special and closely operating forces of sex, development, or decline, and methods of life. This question of temperament, a complex one in the increasing mixture of types—and it would seem of more difficult application in the case of highly pigmented races, where complexion is almost uniform—has nevertheless been retained by some as underlying the whole treatment of medical physiognomy. For it must be seen that if we can estimate "the original vital endowment of the individual" by any conformity of external parts, and calculate the expenditure of his forces in certain directions, we can anticipate failure or resistance, "see in part, and prophesy in part," and the difference in patients will not only be the difference in diseases, but to a great extent an estimate of contributory cause. A correlation between physical structure and vital tendency having been recognized with more or less precision, the classification of temperaments has naturally proceeded upon what have been considered the fundamental resemblances or differences in organization. Advances in physiology and pathology have from time to time enlarged or rectified these boundaries. The nine temperaments of Galen, and the succeeding four of humoral pathology have been displaced by the variable numbers of modern doctrinaires, though the ground now occupied is commonly the same, and the main thoroughfares lie in the same direction. The two following classifications will serve to show the general points of contact and lines of divergence.

Classification of Laycock.[2]—1. Predominant innervation, or nervous temperament.

2. Predominant sanguification, or sanguine temperament.

3. Predominant carbon excretion, or bilious temperament. Associated with muscular activity and good innervation.

4. Tendency to fat formation or deposit without, with good muscular activity, and low innervation and sanguification. Phlegmatic temperament.

5. Comparatively deficient innervation, sanguification, muscular and vascular activity. Lymphatic temperament.

6. Comparatively defective innervation, sanguification, and vascular activity, with tendency to carbon deposit. Melancholic temperament.

This, as will be seen, is an amplification of the older divisions of nervous, sanguine, bilious, and phlegmatic, but based on a refined physiology. As the associated somatic types are substantially given in the succeeding classification it is not necessary to anticipate them.

Temperament, Constitution, or Diathesis, as given by Dr. J. Graham Brown.[3]—1. The Sanguine Constitution. Body well developed, head large, teeth massive and good, complexion ruddy, hair thick, digestion and nutrition good, blood-pressure high. Prone to corpulency and premature signs of old age. Such persons are liable to arthritic affections of all kinds and to diseases of the heart and blood vessels, angina, fatty heart, aneurism, atheroma, apoplexy.

2. The Nervous Constitution. Figure small and wiry, face mobile, features small and delicate, great activity of mind and body, dyspeptic, and with highly strung nervous system. Individuals of this temperament are specially liable to nervous diseases of all kinds.

3. Bilious Constitution. Face oval, long upper lip and chin, long nose, complexion dusky, digestion sluggish, liver in particular being inactive, nervous system not highly strung. This constitution develops into the melancholic. Such persons are liable to melancholic insanity.

4. Lymphatic Constitution. Body large and clumsy, muscles flaccid, face pale and expressionless, movements slow, and functions both of mind and body sluggish.

5. Strumous Constitution. The whole osseous system badly developed, joints enlarged, mucous membranes irritable, upper lip and alæ nasi thick, thorax contracted, skin pale and delicate, and hair thin. Such persons are liable to diseases of the bones and lymphatic glands, and to tubercle in all its forms.

6. Gouty Constitution. Hair early gray, little tendency to baldness; nose short, rounded, and red; cheeks ruddy; eyes generally dark; teeth large and covered with thick enamel; suffers from dyspepsia; heart tends to degenerative changes; arteries atheromatous; early and well-marked arcus senilis. Persons of this constitution are liable to all forms of gout, to the cirrhotic forms of Bright's disease, to neuralgia, and to apoplexy.

7. Rheumatic Constitution. Closely resembles the sanguine. There is, however, a greater tendency to fulness of body and less general vigor. The teeth are liable to early decay.

The easy confusion of the terms temperament and diathesis is shown by this latter classification of Brown, and the question has been fairly raised as to whether what is called temperament is not recognized as such chiefly by the shadow of some morbid change, and when the individual is actually in servitude to some degeneration. Whether, in fact, in speaking of temperament we are not commonly dealing with those phenomena of disease which imply diathesis. The two conditions are distinct, yet the association is close, as the impresses on the two faces of the same coin; and there is need of precision, for it is an unnecessary embarrassment in dealing with this complex subject to retain a term which implies no morbid proclivity whatever. The definitions of Hutchinson,[4] admirable in themselves, will make this distinction clear. Temperament he defines as "the aggregate of a man's physical personality," and elsewhere as "the sum of the physical peculiarities of an individual exclusive of all definite tendencies to disease." Diathesis he pronounces to be "any bodily condition, however induced, in virtue of which the individual is, through a long period, or usually through the whole life, prone to suffer from some peculiar type of disease." The incredulity is not so much as to the existence of temperament, as to our ability to recognize its external signs and characters, modified as they necessarily are by long transmission through constitutions which, however typical at the outset, must in time come to represent a compromise, racial or individual, with various agencies which alter growth and health. If admitted at all into fellowship with diathesis, it should be as a partner of extremely limited and undetermined liability. What we may do with safety and with respect to the precision of diagnosis, is to consider the individual as he is presented, with change of structure or function, from which there is a fair presumption, both as to the controlling power or "tyranny of organization," and its tendency and probable conduct. This is diathesis, and it contributes characteristics of form, structure, and complexion so frequently associated with notable proclivity to certain groups of disease as to be of

diagnostic importance. In the estimate of probabilities it is entitled to the preponderance due to a constantly effective agent. A ruddy complexion with well-developed bones and muscles, a relatively large head and massive teeth, may not signify a gouty arthritis or damaged heart, atheromatous artery or apoplexy, but such a personality should direct the line of search in an obscure case, will often make a local condition intelligible, and may enable us to make a forecast of the future and provision against disaster. So with the accented nervous type, within which we find the victims to overwork, the visceral derangements, dyspepsia, constipation, often the reciprocating lithiasis and neurasthenia, and many of the idiosyncrasies. Here we have the association with small bones of a restless activity of mind and muscle, mobile features, a well-vaulted skull, high forehead, and active eye. The average class distinctions of the strumous and bilious diatheses are confirmed by the same observed affinities for certain local and general morbid processes—although the support of this evidence in some given case may well be found wanting. In the lack of structural symmetry and languor of function we have the marks of the descent of the strumous diathesis from the dominant tendencies ascribed to the phlegmatic and lymphatic temperaments. Its physical characteristics are specially significant, as no other diathesis can compare with it either as to inheritance, or the variety and persistency of its lesions. The skin is fine and transparent, the hair thin and often light in color, eyelashes long and curved, pupils frequently dilated, teeth white and irregular, a bony development tending to a lower ethnic grade, unsymmetrical head, round projecting forehead, prominent malar bones, shafts of long bones slender, with enlarged epiphyses, thick ankles and wrists, heavy fingers with unsightly hands, defective muscular development, a feeble nervous system, capricious appetite, and low nutrition. It has been appropriately called the "inflammable diathesis," and marked by Virchow for its vulnerability—the frequency and intractable character of its glandular inflammations alone being a sufficient justification. With defective nutrition we have diminished growth and lessened resistance, irritable mucous membranes, eczema, local exudations, periostitis, tubercle. The sanguine type of struma is said to be more frequently inherited than the phlegmatic or torpid type, and to be also more subject to the grave issues of phthisis. Still further, under the name of "pretty struma,"[5] a medium type has been described, marked by a fine skin, delicately moulded limbs, sweet and feminine expression; and it is probable that this is the form most frequently met with in this country. Certainly, of coarse struma we see comparatively little. This variety is graphically given in the following description of the candidates presented to Charles II. to be cured by the king's touch. "These which we present to your Majesty," says Wiseman, "are chiefly such as have this tumor about the musculus mastoides or neck, with whatever other circumstances they are accompanied; nor are we difficult in admitting the thick, chapped upper lip, and eyes affected with a lippitudo; in other cases we give our judgment warily."

The readiness of the alliance between the lymphatic and strumous diatheses is so easy, and the former is so dominated by the controlling depravity of struma, that it is doubtful whether their separation is of any practical importance. The large frame and lack of osseous symmetry, the feeble nutrition, the want of muscular and staying power, and the tendency to strumous and asthenic disease are much the same in both types. Absence of energy and intellectual activity are apt to be prominent in persons of this organization. "They are never well," says Fothergill,[6] "in low-lying districts, bear depressants badly, and require stimulants and tonics during illness. The women are liable to menorrhagia and almost always have leucorrhœa, and in parturition are apt to flood profusely." The hæmorrhagic diathesis met with in the families of "bleeders," and which, curiously, shows an almost invariable descent through the female line, is not a derivative from this vascular lymphatic indolence, but, according to Laycock, is a modification of the asthenic arthritic constitution.

With the bilious diathesis we reach the last of the eminently hereditable types, with which there is associated a proclivity to disorder of general process or disease of a special tissue; and it may be said that if this diathesis is entitled to distinction anywhere, it should be in this country, where the accessory impress of malaria is so strong in a large part of the population. Its physiognomy is nevertheless indistinct, the dark coloring of the skin, hair, and eyes, the yellowish discoloration of the conjunctiva, and the generally spare frame being the most pronounced surface characteristics. The oval face, and length of chin and nose may be taken as additionally significant. Bodily development, however, apparently follows upon alliance with other diatheses, having a stronger avowal in structure. There is seldom any tendency to fatten, even at maturity, and abstinence from nitrogenized food is often required owing to the imperfect assimilation of the hydro-carbons. With us the probable association is with the nervous organization, and the result is a composite of spare frame, good muscular activity, mental quickness, and ultimate instability of nerve.

The foregoing diatheses may fairly be taken to represent the influences from which vital endowment is apt to take its chief force and direction; the authorities under which certain morbid tendencies will be found to colonize. They are the larger and more affluent portraits in which will be recognized much that comes under the eye of the physician, and in which, it must be admitted, there is much to baffle us in the mingling of race, inheritance, and the subtle modifications of climate and social condition. To their judgment we must bring a patient study, and familiarity with ethnic peculiarities, the laws of development, transmission of tendencies, and influence of occupation. The perfectly adjusted man, the eukratos of Galen, does not exist as a measure of comparison, a standard of absolute health; but we can become familiar with the physiognomies of men, and note the departures from a just proportion.

There are many other complex conditions arising from the union of the diatheses just considered, from some grafting of acquired disease, or preponderance of special tissue change or alteration of blood; and any one of these may occasionally present a perfection of detail from which it would not be difficult to infer its factors. Of this kind are the compounds of syphilo-struma, the modifications of gout and struma, in which the atheromatous changes predominate, and the hæmic cachexiæ. The chances of identifying these conditions by means of their composite physiognomy alone, or of detecting their subterfuges, must in the majority of cases be small, and the need for more particular testimony is evident.

Passing, then, beyond the broader domain of diathetic groupings, it would still be a plain matter, comparatively speaking, to treat with the physiognomy of special morbid conditions, or the so-called local diseases, if happily there could be found, as with the emotions, any symbolic correlation of expression, such a reciprocal influence as appears between attitude and physiognomy in its ordinary and restricted sense. We might then hope for a measure of the confidence of Laycock, when he asserts that "there is both a physiognomical diagnosis of the viscera, and of particular forms of disease of each viscus." Unfortunately, but few of these pictures can be wholly realized, and, outside of the self-delineations of some forms of insanity, we must accept in principal evidence the often isolated testimony of color, changes of innervation and nutrition, manner, posture, and the facial expressions of pain and anxiety.

It is familiar knowledge, but still an instructive fact, to notice how frequently in descriptive diagnosis the single element of color is selected for emphasis, and this aside from any special pigmentation. Associated with the facial physiognomy of pain, it is a part of almost every clinical picture of acute disease, and it assists in betraying to the practised eye much of otherwise silent and patient mischief.

Before, however, proceeding to notice the hue of the

skin under vascular or other change, it may be well to speak briefly on the subject of complexion, including in this term the color of the eyes and hair. At the outset we are met with the difficulty arising from our ignorance of the proportion of blondes or brunettes in any given population, and in the exact measure of this ignorance we are disabled in drawing a just inference as to the related frequency of any type of disease. There is the additional difficulty of fixing a standard of pigmentation in either case. But there are no conservations, or at least none serving any system, even under a loose definition. Notwithstanding this, there are familiar distinctions, and some interesting testimony and belief. There is an impression that those who have blue eyes, light hair, and fair skin are more prone to the maniacal form of insanity than those of the opposite type of complexion, and that the brunettes show a proclivity to melancholia. Some recent statistics[1] would seem to add substance to this conclusion. The proportion as given is forty-seven of blondes to twelve of brunettes in mania, and in melancholia sixty-one brunettes to forty-two blondes, and this out of a contributing population one-half German. These totals, indicating at best only relative liability, are too small for any purpose but confirmation of inquiry, and, as has been stated, we are under a fundamental ignorance of the numerical relations of complexion to population. Again, occupation, religious belief, and the question of racial psychosis, would have to be considered before the formation of any fair inference. The bearing of the matter upon diathesis is evident. Hutchinson[2] admits that at one time he had formed an opinion that lupus was met with much more frequently in those of dark complexion, persons of dark brown hair, brown eyes, and bluish sclerotic, than in those of a blonde type; but he goes on to explain that this opinion was of purely speculative value, for the very reason just cited, a want of any census of complexion. Elsewhere he states that he has found that among those of dark complexion the need of mercury is greater, the demand for purgatives more pronounced, and the benefit from direct tonics and sea-air less than with those of light coloring. There is also an article of general belief, he says, that when there is a great difference between the color of the eyes and hair, the eyes being much lighter than the hair—as, for instance, black hair with blue eyes—it is an indication of delicacy. We also find it stated[3] that a peculiar somatic type has been noticed as greatly promotive of the amyloid degeneration, "the same suppurative process occurring in a person of blonde and lymphatic type, and in another of brunette and nervo-muscular type, the former will be much more apt to suffer from amyloid damage than the latter." This particular type is strongly designated as "the gelatinous progeny of albuminous parents."

All this is fragmentary evidence at best, and these associations may have nothing whatever to do with the matter of pigmentation, but rather belong to racial proclivity and immunity. Such an immunity we have in the negro to yellow fever, to alcoholism and its results,* and it is akin to the marked resistance of the Jews[4] to epidemic influence, and their comparative freedom from tubercular tendency, whether from racial strength or sobriety of life. However this may be, in the multiple bearings of the case, and the continuity of phenomena, the direction of every drift is worth recording.

Pallor, depending as it does upon the decrease in the volume of the blood, a deficiency in the number of the red blood-corpuscles, or the unfilled condition of the capillaries, has a wide association, and is of varied significance. It may be the "direct" pallor of hæmorrhage, of copious serous effusion into the large cavities, of anæsarca, or the "indirect" blanching of defective nutrition, of acute febrile disease, of grave visceral disorder. Under these varying conditions we meet with the pallor of simple anæmia in young women, often associated with abundant fat, the bleaching of leukæmia, of Hodgkin's disease, of the amyloid changes, and of the various cachexiæ. Of the gradations of color there is a copious nomenclature—the many tints of gray and yellow, earthy, ashen, waxy, straw, buff, and gingerbread—difficult to assign to any scale, but not readily forgotten when once observed. It is probably of some such degraded hue of skin that Hippocrates speaks," when he records that "both men and women who have long had a bad color, but not in the form of jaundice, are subject to headaches, eat stones and earth, and have piles." This observation is old, but the depravity of appetite and color may still be met with. The large white kidney of Bright's disease is said to be accompanied by a peculiar pallor, and in the case of persons of middle age, to be observed along with an unnatural smoothness of skin. Lividity and cyanosis are the skin expressions of embarrassed blood-oxidation, or of passive congestion of the capillaries and veins. They are best seen upon the lips, cheeks, nose, and tips of the fingers, but may be general. These are the stains of obstruction of the upper air-passages, such as croup and spasm of the glottis; of the diminished respiratory area of pneumonia; of emphysema, and asthma. They are seen as unmistakable signs of almost every form of advanced cardiac disease, and if this disease invades the tricuspid valve, the lividity is apt to be marked. In malformations of the heart, permitting the passage of blood directly from the right to the left side, as seen in infants with imperfect closure of the fœtal orifices, during the acts of coughing and crying, or from position, the lividity is frequently extreme, deepening into cyanosis. It is probable that these degrees of discoloration, coupled with other signs, may enable the skilled observer to separate the cardiac from the pulmonary expression, but dependence cannot be placed upon the color of the skin alone.

The yellow or saffron staining of jaundice, from retention of bile-pigments in the blood, is a commonplace observation, the conjunctivæ and finger-nails sharing in the discoloration. In the bronzing due to disease of the supra-renal capsules—Addison's—however much may be the pigmentation of the skin, the conjunctiva of the bulb and the nails are never involved. Local pigmentation, chloasma, is also seen in pregnancy, and is not infrequent in disease of the female organs of generation. Argyria, the blue or gray stain from the long administration of nitrate of silver, is now so seldom seen that it has become historical, and it is probably known to most through the misfortune of the hero in Wilkie Collins' novel of "Poor Miss Finch."

Increase in the natural redness of the skin may usually be taken as a mark of plethora, or if local, of exposure to the weather, the febrile color and that of inflammation being in general readily distinguished from it. The circumscribed redness of the cheek in pneumonia, the pneumonic spot, and the malar flush of phthisis, are well-known vascularities, and, like the reddening of the face in hemicrania, are due to vaso-motor disturbance.

Facial Expression.—In his ingenious and interesting work on "Facial Expression," Warner[13] gives as the results obtained from an examination of the face: 1, The passive conditions resulting from heredity; 2, the present trophic condition; 3, the marks or permanent impressions made by the nervo-muscular actions during life; 4, the nervo-muscular condition at the time of observation. To these there should be added the traces of past disease other than those relating simply to heredity or innervation. From this grouping of conditions we get the resultant expression, which is a general balancing of all the factors, and in which each factor is assigned its due value. The faces of children would not, of course,

* Reports of Surgeon-General, U. S. Army: [illegible]

	1885.		1886.	
	White.	Black.	White.	Black.
Mean strength of troops	21,749	2,295	21,944	2,194
Admissions and results, ...	1,486	7	1,284	8
Ratio per 1,000 of mean strength	68	3	59	4

With every allowance for relative sobriety, the racial exemption of the negro is marked.

[1] Wilkins, Journal of Mental Science, April, 1886.

[2] Hutchinson, Archives of Surgery, vol. i, p. 1.

[3] Wilks, Pathological Transactions, vol. xxxvi, p. 1.

[4] Hirsch, Handbook of Geographical and Historical Pathology, vol. i, p. 75.

[13] Warner, Facial Expression, Philadelphia, 1886.

present marks of such motor change as we should expect in the countenance of an adult, from pain, anxiety, or habits of life. The impress of inheritance has already been briefly discussed, and the remaining conditions will be found to align themselves with the analysis as we proceed.

In dealing with the innervation of the face, we may look with some confidence for the evidence of anxiety and cerebral irritation in the upper facial zone, about the forehead and eyes; and for the expression of bodily pain in the lower zone, or the region about the nose and mouth. Indeed, it is in this latter region that acute abdominal pain pre-eminently may be said to be specialized. In this way peritonitis is indicated by the raising of the upper lip and partial exposure of the front teeth, the risus sardonicus; and it is here that we catch the fleeting "twitch of abdominal pain," to which attention has been called, and whose study in the parturient woman is recommended. It is needless to say that we may have the whole face thrown into violent action in excess of pain, or in convulsive disease, and in such cases the differentiation is readily made by other means. The transverse rugæ of the forehead, under the control of the occipito-frontalis muscle, the oculo-frontal folds produced by the corrugator supercilii, the linea nasalis of De Salle, and the oculo-zygomatic line of Jadelot, have all been followed to forced and fantastic conclusions; but their place upon the facial chart should be remembered and studied. Sir Charles Bell has shown how the muscles about the eyes are closed involuntarily during violent expiratory efforts, such as coughing, in order to protect these delicate organs from the increased pressure of the blood; and there is abundant and suggestive proof, in the analysis of emotional expression by Darwin, of the value of this neglected sign-language. The observations of Jadelot, made in the Foundling Hospital of Paris, and so applied in the diseases of children, where the guides are few, are entitled to special study and consideration.

Alterations of the face from mimetic spasm, or from facial paralysis, though pictorial enough, are not in themselves convincing as to the cause or location of lesion, whether central or peripheral. Convulsive tic is commonly a reflex, but it may be subordinate to a wider convulsive movement, such as hysteria, chorea, or epilepsy. Association with related conditions must determine the diagnosis. From the simple "wink" to a riot of diffused spasm, there may be seen every conceivable grimace of the harlequin. In connection with severe neuralgia, there may occur a slight contraction of certain muscles of the face, resulting in a fixity of expression which has been called the "histrionic spasm," as if the patient were acting a part. The contraction in such cases is sustained.

Paretic alterations of the face are more or less distinctive, but can rarely be called pathognomonic. The hemiplegic, if incomplete, will have chiefly the lower zone of the face astray, among the muscles for unilateral use; the corner of the mouth will droop, and the naso-labial fold will be more or less effaced; whereas in the complete unilateral paralysis of the face (Bell's, Fig. 1125, vol. iii.), due to impairment of the portio dura, the muscles for bilateral use are involved as well. As all the principal muscles of expression are supplied by the seventh nerve, quiet and effacement follow the motor weakness or palsy. The forehead is smooth from the impairment of the frontal muscles and those about the orbit; the eyelids cannot be brought together, the upper lip cannot be raised; whistling becomes impossible, the saliva dribbles, and food accumulates between the teeth and cheek. The unopposed action of the muscles upon the sound side of the face, with extinction of action on the other, contribute a two-fold expression at once pathetic and diagnostic. It is interesting to note here that, in receding paralysis, the power over the brow and eye will be regained first, that over the mouth and lip last. The gain is in favor of the more intellectual over the more animal zone of the face. Simple muscular relaxation from fatigue, anxiety, or disappointment, answers to the "chop-fallen" appearance; but with paralysis we have actually a lengthening, sometimes of three-fourths of an inch,[14] making the "long" face no longer a metaphor. The corresponding changes under the depressing influence of frequent headaches, or of poor innervation, are of common occurrence.

As the characteristics of idiocy are those of arrested development, or return to a lower "ethnic form," a type of retrogression and default, we should expect to find a face expressive of both mental and physical degradation. The microcephalic head, with retreating forehead and chin, and projecting mid-face, Fig. 1832, is a type of this debasement. The nose is often large and misshapen, the mouth wide, the lips coarse, the teeth irregular, projecting, and carious; the eyes are oblique, with excessive development of the epicanthic fold, or third eyelid of the bird, and the ear is frequently defective. The microcephalism does not occur in all cases of congenital idiocy, but there will be traces enough of the physical and psychical ruin to distinguish the average idiot, who, short of annihilation, is apt to suggest a complacent automaton. In purely accidental idiocy, these bodily changes are not to be expected.

Although etiologically the cretinoid idiot, whether goitrous or not, as a derivative from unwholesome endemic influence and vice of progenitors, offers a different problem from that of idiocy by arrest, yet similarly the product is one of marked degeneracy and peculiar physiognomy. "The diagnosis of cretinism," says Langdon Down,[15] "may be made in childhood from the slowness of the development of the body, the stupid expression, the postponement in the evolution of the teeth, and of the ossification of the fontanelles and sutures, the tawny, yellow color of the skin, the thick and goitrous neck, the slavering, and the delay of speech and walking." According to the same authority, the adult presents a still more repulsive and distinctive appearance, to which the large, expressionless face, with drooping jaw, lolling tongue, oblique and squinting eye largely contribute, along with the unsymmetrical and ill-developed head.

Though of undetermined causation, and, on the basis of unquestioned cases, exclusively a disease of adult female life, it seems probable that we have in myxœdema an ally of the cretinoid state. While with this selection, its characteristic invasion, and fortunate rarity, this remarkable mucous overgrowth is not likely to embarrass a differential diagnosis, its characteristic physiognomy is certainly worth study and recollection. Perhaps torpor conveys the best idea of its totality, but the elements of the expression are peculiar. The description of Dr. William Ord,[16] to whom we are indebted for the definition and much of the precise study of mucous œdema, is entitled to full quotation. "The face," he says, "is swollen in every feature, so as to suggest the existence of renal disease; but the distribution and quality of the swelling are different from what is observed in common dropsy. The swollen skin is singularly waxy-looking and anæmic, and the swelling affects dependent and non-dependent features equally. Thus the upper and lower eyelids and the upper and lower lips are uniformly enlarged; the alæ nasi are thickened and broadened; the ridges of expression are blurred and coarsened, or the lines obliterated. The cheeks are overspread with a dull pink flush, abruptly limited toward the orbits, and standing in vivid contrast with the anæmic skin around. The face wears a fixed, heavy, and withal most sad, expression." Early decay of the teeth is noted, related no doubt to the trophic condition of the skin and mucous membranes. There is much in this detail of signs involving consideration of voluntary movements, intellect, and errors of special senses, to which the reader is referred for a full portrait of this disease.

The insane face Hamilton has epitomized as one of inconsistency of expression, quoting at the same time Tuke's simile of "a face formed of children's blocks, the upper half with a pair of serious eyes, and the lower half with a laughing mouth." There is also in the insane expression a dramatic quality and an ease of rapid transition, which, as Spitzka[17] has remarked, make it of all the

signs of insanity the most difficult to counterfeit. The errors of expression are those of excess in one direction or the other—the patient is too gay, or he is too sad. The gloom of the melancholic is unmistakable in his face, in the depressed corners of his mouth, his lowered eyes, and the general relaxation of his facial muscles; and these signs are as typical of his distress as his bowed head and solitary thought. Opposed to this is the flush, the restless activity and frequent turbulence of mania, the face at one time scowling or snarling with rage, at another wreathed in a superfluous smile. It may be said that to each monomania belongs a look in some degree corrélative to the dominant idea. The religious lunatic, the nymphomaniac, and the monomaniac who thinks himself a king, each illustrates without concealment the supreme delusion. In dementia the face partakes of the general apathy and immobility, and often in the muscular relaxation scarcely an emotion stirs.

It is important to remember that in any case where the insane face is studied, its possible alteration from paresis of one or more muscles must be considered. As marks by which the insane diathesis or neurosis may be recognized in any inquiry, there have been pointed out irregular and unsymmetrical conformation of the head, a want of harmony of the features, and malformations of the external ear. The convulsions which are frequent in early life leave behind them spasmodic movements of the face, eyelids, and lips; and Maudsley has recorded a look half fearful, half anxious, suggestive of the look of an animal, a questioning expression which is frequently to be caught.[18]

The police courts occasionally have to deal with prisoners, chiefly young men, whose sexual perversion has led them into some offence against decency. Along with their mincing gait and soft, high voices, the feminine expression, with absence, or defective growth, of hair upon the face, is characteristic of these masculine courtesans.

A few remarkable facial expressions have passed into medical literature under permanent names, which by common consent are taken in themselves as completely descriptive of the conditions they typify. The senile face of hydrocephalus, with its overhanging forehead, recessed eyes, and dwarfish jaw and chin, is of this class. The facies stupida or typhoid face, the pinched countenance, *facies grippée*, of peritonitis, and the Hippocratic face of impending dissolution, are familiar examples of this pictorial kind. Then there is the face expressive of well-advanced ovarian disease, the "facies ovarina," of which Spencer Wells[19] gives a graphic description. "The emaciation, the prominent or almost uncovered muscles and bones, the expression of anxiety and suffering, the furrowed forehead, the sunken eyes, the open, sharply defined nostrils, the long, compressed lips, the depressed angles of the mouth, and the deep wrinkles curving round these angles, form together a face which is strikingly characteristic." In the insidious shock of severe gunshot wounds and grave injuries to the joints, but seemingly not dependent upon special regional injury, an expression is sometimes met with that is a curious mingling of anxiety and tranquillity, and is of the most serious import. "The countenance of the patient is altogether unnatural. It presents an inquiring, anxious look about the forehead and eyes, and upper portions of the face, while all about the mouth and lips is smiling and composed." With simply a frettul complaint, a soldier in this state of blunted sensibility has been known to ask only for the removal of the weight of a piece of shell lying partially exposed in his abdomen.

Numerous other examples of facial expression might be given, in which the varied morbid conditions of blood, nerve, or nutrition find a complete or partial illustration; as there are many in which the finer shades of meaning may be said to appear upon the face simply as apparitions. The mechanical fixity of catalepsy, the stupor of narcosis, the fatuous look of commencing alcoholism, the death like face of syncope, the emotional quiet of some forms of mild hysteria, and the distortions of the graver forms, are all commensurate illustrations after their kind. It will often happen, however, that outside of the collective evidence of the face there may be a single feature which can be taken as a competent witness apart from others. The eye, nose, mouth and teeth, ears, and, in the region of more general physiognomy, the neck and hands, have each of them at times important information to give.

Eye.—We are doubtless in the habit of attributing many meanings to the eye that belong properly to the associated action of the lids and brow, so that if we dissociate the eye from the mobile region in which it is placed, it will be found, apart from structural disease, to have but limited expression. It is only necessary to conceal the rest of the face, as with a mask, to realize how much we depend upon these accessories for the recognition of the varying expressions and emotions with which the eye itself has been endowed. Its range of separate expression, then, is not great. The oblique position of the orbit in idiots and imbeciles, giving to the eye and face alike a Mongolian cast, has already been noticed as a lower ethnic reversion. In exophthalmic goitre, Graves's or Basedow's disease, the prominent staring ball is pathognomonic. It is easily distinguished from the ordinary staring eye, as in fear, due to the uncovering of the ball from the action of the lids. Changes of the conjunctiva in jaundice, in profound anæmia, and as the result of increased vascularity, will readily suggest themselves as part of a general condition; and the altered appearance of the eye in cataract, glaucoma, pterygium, or from destructive change, does not need description here. The motor changes are more numerous and more demonstrative. Clinically, the various forms of strabismus, whether paralytic or due to spasm, must always be separated. As any disease at the base of the brain may paralyze the muscles of the ball, the diagnosis of the particular lesion must rest on further inquiry. The motor control of the third, fourth, and sixth nerves will be remembered, as to probable indication both of the locality of the disease and of the nature of the disease itself. Thus paralysis of the fourth nerve, supplying the superior oblique muscle, is usually due to syphilis, and impairment of the sixth, supplying the external rectus, when in combination with patches of anæsthesia in the region of the fifth, is said to be specially suggestive of specific lesion. Habitual deviations of the head, instinctively assumed to combat the results of errors of vision depending on ocular paralysis, will often suggest the associated form. Divergent strabismus may generally be taken to indicate the simple release of a visually defective eye from control in the absence of impressions.

The pupils are dilated in syncope, dyspnœa, hysteria, hydrocephalus, in melancholia, often in epilepsy, and by various mydriatic drugs. In paralysis of the third cranial nerve, besides ptosis of the lid, there is moderate dilatation of the pupil, the two constituting a well-known sign. A paralytic condition of the pupils is also frequent in locomotor ataxia, in which case, though contracting for convergent vision, the pupils are not responsive to light. This is an abolition of the pupil reflex, and constitutes the Argyll-Robertson symptom. In profound alcoholic poisoning, cerebral apoplexy and concussion, in uræmia, and in poisoning by opium, the pupils are more or less contracted; but, except in the narcotism of opium, where the pin-hole pupil is found, this sign alone is an insufficient guide to diagnosis. Extreme contraction of the pupils will be met with in cases of hæmorrhage into the pons Varolii, but other signs—such as the crossed paralysis of this lesion—will serve to distinguish it from mere opium narcosis. Unilateral contraction of the pupil will often exist where there is pressure upon the cervical sympathetic, from aneurism or other deep-seated disease of the neck. The two forms of arcus senilis, the fatty and calcareous, must be carefully separated; the former raises a question of fatty degeneration of the heart, while the latter is consistent with excellent health, and may frequently be seen in the eyes of hearty old men.

Nose.—The instruction to be gathered from the nose depends mainly upon its shape and nutrition, the rapid action of the alæ in labored breathing being the chief exception. The damage of inherited syphilis may leave

the bridge flattened, or the thickened alæ nasi lead to a conviction of struma. A monstrous and misshapen nose is a common inheritance of idiocy. The tuberous nose of the drunkard is suspicious, but may be simulated by disease, as in hypertrophic acne; and the red tip in women is said to be associated with indigestion and constipation, and frequently with pelvic derangement. The nose "sharp as a pen" is a contribution by Shakespeare to the Hippocratic countenance. It may be noticed here, though of no significance, that the nose is rarely symmetrically placed, or rather, that there is usually a deviation from the straight line generally to the right. Whether this is determined by the use of the right hand for casual service is uncertain, though probable.

Ear.—Laycock [21] placed great stress upon the development of the external ear as significant of a corresponding condition of the brain. The circulation and nutrition of the tissues of the ear lobule and those which cover the helix he conceived to commonly coincide with similar states of the encephalic tissue; and he taught that the development of the cartilage of the external ear was also in relation to the cranial growth of the individual. The confluent ear and adherent lobule he pointed out as often associated with cerebral deficiency; and as a mark of good health and good nutrition he openly preferred the well-marked ear as a general guide. As an index of the state of the circulation it is certainly a valuable aid, but it must be remembered that the ear is much more exposed to the influence of the outside temperature than the lips, and so far this evidence is the less reliable. As an indication of gout the ear may reach a diagnostic value in its tense, red, and shining skin, or from the presence of small concretions, otoliths, beneath the skin of the helix. Of lesser moment, but generally accepted as distinctive, is the "insane ear," which has shrivelled and withered after the effusion of hæmatoma auris.

Teeth.—Attention has been called to the diagnostic importance of indications afforded by the teeth, chiefly through the observations of Hutchinson in congenital syphilis. The characteristic malformation is in the upper central incisors, and consists "in a dwarfing of the tooth, which is both narrow and short, and in the atrophy of its middle lobe." The lower incisors are left narrow and peg-like. The notch in the upper incisors is thus vertical, and not horizontal. Any severe arrest of development in the early nutrition of the permanent teeth may produce the horizontal furrowing, as we see it upon the nails after illness, and sometimes the teeth are deeply pitted; but these marked and craggy teeth must not be confounded with those showing the crescentic notch, a condition absolutely diagnostic of inherited syphilis. Early decay or loss of the teeth is both a sign and cause of unsound health, and may signify one of the various cachexiæ. It is, of course, necessary in any observation of the teeth to be assured that they are not artificial.

Additional or corroborative information of disease may be gathered from other portions of the face, and this will happen chiefly in diathetic conditions. The broad, square, prominent forehead of rickets, with its tracery of veins under the transparent skin; the arborescent vascularity of the cheeks that tells of gout or atheroma; the tortuous temporal artery of habitual cerebral congestion, often seen in the student, or perhaps significant of arterial wall change; the pigmentation of the lids and areola about the eyes in pregnancy and menstrual disorder; the full lips of struma, and the coarsened mouth of sensual indulgence, are opportune testimony in one way or another. Explanation of œdema of the face, whether distributed or confined to the loose areolar tissue of the eyelids, should be sought generally in cardiac, renal, or liver disease—less frequently in simple anæmia—or some obstruction to the venous circulation within the chest, as from an aneurism, or glandular swelling in the mediastinum. The equal encroachment, as to dependent and non-dependent parts, will serve to distinguish the puffiness of myxœdema.

The whole field of facial expression is most interesting, productive, and worthy of thoughtful study. Testimony as to its value is strongest from those who have been the most diligent and capable observers. "It is occasionally," says a distinguished teacher, "almost our sole dependence in diagnosis. Through it we sometimes recognize the existence of pain, mental anxiety or depression, insanity, and even, in a general way, pectoral or abdominal disease, when other signs are either wanting, obscure, or not available. In the cases of children, of the insane, and of persons who may be disposed to deceive us, it is a particularly valuable resource. Many diseases are attended with a characteristic aspect of countenance, which will often be recognized by the experienced so far as to suggest the disease to his mind. But it is only by experience and close observation that this power is attained."

As parts of the surface exposed to immediate view, the hands and neck should not escape the attention of the thorough observer.

Hands.—The hands may betray the constitutional conditions of struma, gout, rheumatism, or phthisis. To the strumous hand the slender shafts of the phalanges, and the exaggerated epiphyses, give an unsymmetrical and coarse appearance. "Such was the fist," says Fothergill, "of the great lexicographer, Dr. Johnson, who also had a strongly marked strumous face." In gout the deposit of the urates in the joints, or the inflammation of the sheaths of the tendons, produce results, from enlargement and contracture, that are characteristic. The so-called "clubbed fingers" may occur in cardiac disease or in phthisis, but the latter is the ordinary association, as the result is one of waste. In myxœdema, Sir William Gull has given the comparison of "spade-like" to the swollen deformity of the hands; and those who have seen the distortions and dislocations produced by arthritis deformans, need not be reminded of the grape-vine twisting of the fingers as a part of the ruin of that unhappy disease. (See Figs. 1574, 1575, 1576 in vol. iii.) The irregular and purposeless movements of the fingers in athetosis are said to be diagnostic, being slower than the jerks of chorea, and not mimicked by hysteria. The gradual flexion and extension are grotesque, the fingers occasionally crossing one another, and looking like an "automaton pulled with strings, or the movements of a boneless limb, such as an elephant's trunk, or an anemone's tentacle." Charcot has abundantly described the flexed hand and contracted fingers of amyotrophic sclerosis, and assigns this condition to a lesion of the pyramidal tract. The "main en griffe," or bird-claw hand, a local expression of progressive muscular atrophy through the wasting of the interossei, is familiar through the delineations of Duchenne.

Occupation must always be taken into account in any estimate either of the shape of the hand or condition of its tissues, as certain characteristic disorders, principally of innervation, are produced in this way. The wrist-drop of saturnine palsy is an example of this kind; and the cramps and pareses of penmen, pianoforte players, and milkers, will naturally occur to the reader.

Postures of the hand have not received the attention they deserve, being for the most part expressive rather of general nerve debility or irritation than of established disease. Representations of this kind are shown in the typical positions of the feeble and nervous hand, as drawn after Warner (Figs. 1557, 1559, in vol. iii.) Observations of this kind are useful in the general count of vague functional debility.

Nothing can be added to the picture drawn by Hippocrates of carphologia, or the aimless motion and waving of the hands in delirium of the gravest import. "I have made," he says, "these observations upon the movements of the hands. In acute fevers, in peri-pneumonias, in phrenitis, and in headaches, the hands moved to and fro before the face, seeking in the void, as if gathering bits of straw, picking at the coverings, or detaching objects from the walls of the room, constitute so many signs of a fatal termination." And they do.

Neck.—The neck should be observed both as to its general characteristics and the evidence of its surface. The latter may present a typical thyroid enlargement or atrophy, the cicatrices of old scrofulous abscesses, some

muscular contraction, or, in the pulsation of its arteries and veins, proof either of aortic or tricuspid regurgitation.

The long neck is said to be associated with the "expiratory" form of chest, and to denote a want of vigor, and often a tendency to tubercle. In this form of chest the sternum is depressed, with widening of the upper, and narrowing of the lower, intercostal spaces. On the other hand, the short neck carries with it an assurance of robustness, through its relation to the "inspiratory" chest; there being, however, an idea that, owing to the close approximation of the brain to the heart, and the additional strain upon the cerebral vessels due to this condition, the short neck renders its possessor, in later life at least, prone to the danger of apoplexy. It would seem wiser, as to this latter fear, if the association is well determined, to refer it rather to the tissue conditions accompanying this configuration than to the action of dynamic forces.

Posture.—Voluntary postures, in a medical sense, are chiefly protective. That is, they are assumed to procure physical relief. Of this kind are the modified upright positions which the patient instinctively seeks in cardiac or pulmonary embarrassment, sitting supported in the bed, or even in extremity upon a chair, with the head resting in front. So with any disease that impedes respiration, such as the pressure of an aneurism, or the encroachment of abdominal dropsy; the respiratory need demands a position in which the accessory muscles may act freely. The round and raised shoulders of the asthmatic and emphysematous are fixed by this expiratory habit. The position characteristic of acute peritoneal pain is eminently protective, the patient lying on the back, with knees drawn up, in the effort to relax the tension of the abdominal muscles and walls. In unilateral disease of the lung, the decubitus is ordinarily upon the affected side, and the position of great prostration is marked by the inability to maintain even the slight angle upon the pillow.

Postures enforced by convulsive or paretic disease are likely to be striking and effective, owing to their plain departure from what may be considered the ordinary state of equilibrium, or of emotional attitude. Occasionally there seems to be a dramatic or purposive element in some of the postures, as in the crucifixion attitude of hystero-epilepsy—a quality that will be found lacking in the forms of pure tetanoid rigidity; and the presence or absence of this element will be duly suggestive. In sharp contrast to the alternating postures of convulsion are the petrified or frozen attitudes of catalepsy, where the limbs retain any position in which they may be placed—a state of "plastic rigidity," as it has been called. Paralysis of a limb or side will destroy symmetry both of form and movement, and positions will be sought which are at the same time compelled and protective. The peculiar "climbing the thighs," to which the victims of pseudo-hypertrophic paralysis resort in their efforts to resume an upright position, and their method of balancing when erect, are among the attitudes absolutely pathognomonic. Other neuroses are prolific in transitory expressions of posture, picturesque, but of no diagnostic value.

Gaits.—As might be anticipated, we must look to those whose walk has been altered by brain or spinal disease for the typical gaits. Necessarily, they are most characteristic of lesions of the cord, and depend upon regional damage for certain of their peculiarities. The inco-ordination of locomotor ataxia finds ample expression in the sufferer's gait. Loss of cutaneous sensibility, and the necessity for supplementary control, require the ataxic to keep his eyes upon his feet, or upon the ground immediately in front. Supported by two canes, he moves with slow, deliberate, but unequal and jerking, steps, the knee stiff, the point of the foot thrown forward, and the heel brought down with a stamp. He is unsteady, not in his head, but in his legs.

In the earlier stages of spastic paralysis, while the patient is still able to walk about without the aid of sticks, the gait is made extremely peculiar through a combination of leg paresis with reflex spasm of the muscles of the calf. The feet seem to cling to the ground, and the leg is moved as a whole by raising the pelvis. The result is a singular hopping elevation of the entire body, the patient leaning heavily, first upon one stick and then upon the other, and seeking to aid the lifting of the trunk by the movement of his arms. A variety of this stiff spastic gait is seen in the "high action," or "equine," movement, in which there is an effort as if to flex the thigh on the abdomen at each step.

The paretic or paralytic gait is the outcome of more or less extensive palsy of the lower extremities. It is characterized by shuffling; the tip of the foot drags, and the sole is planted awkwardly, usually with its outer edge first; the knee is raised high or drawn along in an extended position. The patient stands quietly, totters but little, but often falls if left unsupported.

The festination or propulsive gait of paralysis agitans is an exact fulfilment of its name. There is notable hesitation before a start is made, then a few deliberate steps ending in an increasing hurry, as if, as the phrase is, the patient was endeavoring "to catch up with his centre of gravity." The whole proceeding may end in a fall, or collision with the wall, or some object about the room.

The so-called "cerebellar gait," in which the feet are widely spread apart for support, and the movement is staggering from the accompanying vertigo, has been shown by Nothnagel to depend upon disease, chiefly tumor, of the middle lobe of the cerebellum.

This list of the signs which disease displays either habitually or casually is far from exhaustive. There are many changes of the surface and manner which the recollection of the exanthems, the skin hypertrophies, and anasarcas will recall, but whose extended discussion is not now profitable. There is no intention to produce a morbid panorama, but the effort is rather to connect the individual with certain forms of fundamental diathetic influence, which are conceived to determine much of his structure, as well as his conduct under the stress of special disease liabilities; his compromises, if you will, with acquired tendencies, and the probable cause of ultimate failure, and beyond this, to give such portraits of morbid conditions as may be readily recognized. All this is a sign-language, not regulated by any conscious intelligence, and therefore difficult to formulate, but which after use will clear itself of much ambiguity, and fall readily within the order of physical diagnosis.

If it were required to set apart and appraise those signs of medical physiognomy likely to be of most service to the practitioner in that general estimate of the patient that precedes a minute inquiry—the *coup-d'œil médical*, as it has been aptly termed—the characteristics of the main hereditable diatheses should be selected as of most immediate and suggestive value. They will not always be superficially distinguished, but they will be found such ready interpreters of complex conditions as to reward a search behind more intrusive phenomena. An obstinate bronchitis may thus be found to rest upon an underlying tendency to gout, or allied lithæmic condition, and appropriate treatment will be at once suggested. It is the relation of soil to production.

It is often urged that the physical portraits of diatheses are overdrawn, that they are diagrammatic, and represent rather the extremes of configuration and attributes than the desirable and serviceable means. This objection may be true as to the individual; it is not true as to the race. The delineation of struma, for instance, expresses the most general and constant of those traits which in any selected individual will have less range and less precision. So with the other diatheses. And it is precisely here, and as an aid in fixing the images of these class conditions, that the composite portraiture of Francis Galton[24] seems to offer its greatest usefulness. In the disappearance of the individual, and the reinforcement of common attributes, we get a resultant, *air de famille*, that is truly a "generic portrait." Pictorial statistics Galton calls them. The application of this method to the consumptive and criminal face[25] has already given most instructive results, and it is reason-

able to hope that we may get helpful portraits of the various diathetic countenances, the myopathic face,[26] the face of epilepsy, of chorea, of idiocy, of mania or melancholia, and the many nervo-muscular conditions which in large hospitals, asylums, or reformatories repeat themselves in such numbers as to be available for research of this sort.

It is not necessary to renew here the argument for the recognition of temperaments, or to assert their relation to our present inquiry. It is perhaps, as Finlayson[27] says, an effort "to pour the new wine of physiology and pathology into old bottles." The usefulness of the exertion cannot, however, be questioned, although the results may be spurious or elusive. Still it is clearly material whether we take a man's endowment as clear of debt to any morbid tendency, or with certain defined inherited burdens. In the latter case, and dealing with diathesis, we are fairly on firmer ground. As to the personality of gout and struma, there is little doubt or discussion. Their somatic types are well defined, and their tendency to reproduction in offspring very great, probably fifty per cent. In alliance with other types they are more apt to dominate than to be submerged. The personalities of the bilious and nervous diatheses are not so well bounded, and their tendencies are more to functional deviation than to change of structure. Predominant innervation of the one and the predominant carbon excretion of the other have their gradients on the one side to the various neuroses, and upon the other to disorders of digestion and defects of assimilation. So much may fairly be advanced, and the importance of so much will be found of practical significance. Doubt may fairly be expressed as to the value, or rather as to the propriety, of admitting a lymphatic type to special distinction. Its separation from struma, either as to the structure of the class or the behavior of its tissues, is so debatable that the territory may be considered in common. Too much differentiation in the matter of diathesis is unwise. The tendency to erect separate types out of the composites of the predominant forms is attractive to some, but should be resisted as leading to obscurity, and a ready escape from definition into evasive and transient conditions. It is not easy to overestimate the clinical service of an insight into the physiognomy of diathetic disease, whether for the ends of treatment, the detection of feigned or concealed disorder, or for such specialized work as falls to the lot of the examiner for insurance. It is the product of research, and correction of results by other physical diagnosis, in its nature supplementary, and often a critic of the conclusions reached by more formal methods.

Beyond this penumbra of diathesis we have, as has been briefly shown, a multitude of local, regional, and general disorders, with more or less complete and characteristic physiognomies, the varied tints of the skin in the cachexiæ and in visceral disease, the facial expressions of cerebral, thoracic, and abdominal derangement, alterations of nutrition, spasms, tremors, significant attitudes, and gait. To these might be opportunely added a consideration of the relative height and weight of the body as a test of its physiological condition. Any one of the indications afforded by these signs may be as conclusive of structural disease as the most valuable and credited physical indication.

We have, then, in the study of medical physiognomy, to consult many contributory forces, racial proclivities, the pressure of inheritance, the influence of sex, occupation and social condition, and, finally, to deal with special expressions. It has been well said that "the accurate observation of many combined influences, native and accessory, which must furnish the interpretation of much of the behavior of the individual in illness, has been called the stumbling-block of practice," and that it were better to make it "the touch-stone of medical skill."[28] No contribution to this accuracy is worth more than a recognition of the outward signs of these native and accessory forces.

Despite Sydenham's assertion that it makes no difference in the phenomena of a disease whether Socrates or a simpleton is sick, the fallacy is a matter of the simplest experience. No such equality can be admitted mentally or physically, and we must learn to distinguish the physiognomy of the one from the other. This knowledge is within reach; and in the restricted sense that the simile implies the inheritance of the man, the use to which this endowment has been put, and the way in which he has acquitted himself under inherent and acquired tendency, we may accept from the exalted imagery of Swedenborg the illustrative lesson, that "a man writes his life in his physique, and thus the angels discover his autobiography in his structure."

A few words as to the bibliography of this subject, upon which the purely separate treatises are few. Of the first rank are the lectures of Dr. Thomas Laycock, on the "Physiognomical Diagnosis of Disease," in the *Medical Times and Gazette*, 1862, vol. i., and the "Medical Observation and Research" of the same author. Fothergill has extended a similar treatment in "Semeiology," part I. of his "Aids to Diagnosis," in his "Maintenance of Health," and the "Principles of Therapeutics." Restrictions and cautions as to Dr. Laycock's conclusions are ably presented by Hutchinson in the "Pedigree of Disease," embracing six lectures on "Temperament, Idiosyncrasy, and Diathesis," London, 1884; New York, 1885; and further by Finlayson, in the opening chapter of his "Clinical Manual," London, 1886, upon the "Physiognomy of Disease." Dr. George Corfe, in the *Medical Times and Gazette*, 1867, vol. i., has recorded his "Observations on a New Method of Illustrating Diseases by Physiognomic Portraits;" and, finally, the "Kranken Physiognomik" of Baumgartner, Stuttgart, 1842, has attached eighty colored plates of more or less value. On the closely allied subject of temperament, we have Galen's "De Temperamentis;" a section by Wilks, in his paper on the "Nature of Disease," "Guy's Hospital Reports" for 1869; a series of articles by Dr. Southey in the *Lancet* for 1878, vol. i.; one by Dr. Prichard, in the "Cyclopædia of Practical Medicine;" Drs. Forbes, Tweed, and Conolly, vol. iv., London, 1835, and one by Dr. Ord, Quain's "Dictionary of Medicine," New York, 1885, pp. 1596, 1597. Of much direct and collateral interest will be found the researches of Charcot and Richer, in facts of cerebral automatism; of Duchenne, in the Mechanism of Physiognomy; Darwin's "Expression of the Emotions in Man and Animals;" Warner's "Physical Expression;" the essays of Sir Charles Bell on the "Anatomy and Philosophy of Expression;" and the work of Lavater upon "Physiognomy." Composite Portraiture and Photography, in their medical application, are treated by Mahomed and Galton in "Guy's Hospital Reports" for 1881; at length in Galton's "Inquiries into Human Faculty;" and there is some instructive work upon the "Criminal Face," by Dr. H. D. Wey, physician to the New York State Reformatory, in the report of that institution for 1886, printed in January of this year. Reports of medical examiners in life insurance, as to recognition of diathesis, and works on anthropometry in relation to growth and weight, will suggest themselves as of value. *Dallas Bache.*

[1] Clinical Lectures on the Physiognomical Diagnosis of Disease, Med. Times and Gazette, Lond., 1862. [2] Op. cit.
[3] Medical Diagnosis, pp. 21, 22. Birmingham Co., 1884.
[4] Pedigree of Disease, pp. 3, 4.
[5] Pepper's System of Medicine, vol. ii., p. 244.
[6] Semeiology, 1884, p. 14.
[7] Keenan: Journal of Mental and Nervous Diseases, April and May, 1886. [8] Op. cit., pp. 12, 13.
[9] Pepper's Sys. Med., vol. ii., p. 1041.
[10] Surgeon-General's Reports, U. S. Army, 1885, 1886.
[11] Richardson: Diseases of Modern Life, pp. 19, 20.
[12] Adams' translation. [13] Physical Expression, p. 199.
[14] Op. cit., p. 202. [15] Quain: Dictionary of Med., p. 315.
[16] Op. cit., 1015. [17] Insanity, p. 74. [18] Body and Mind, pp. 58, 59.
[19] Reynolds' System of Medicine, vol. v., p. 862.
[20] McClellan: Prin. and Prac. of Surgery, p. 19. Phila., 1848.
[21] Op. cit.
[22] Wood: Practice of Med., 1858, p. 197.
[23] Ranney: Practical Med. Anat., pp. 155, 156.
[24] Inquiries into Human Faculty. New York, 1883.
[25] Galton: Op. cit. Dr. Wey, in Report of N. Y. State Reformatory, 1886.
[26] Landouzy: Note sur le facies myopathique. Bull. et Mem. Soc. Méd. des Hôp. de Paris, November 3, 1886, pp. 419-428.
[27] Clinical Manual, p. 14. [28] Dr. Ord: Quain's Dic. Med., p. 1597.

PICROTOXIN (*Picrotoxinum*, U. S. Ph.). The neutral, crystalline, active principle of the seed of *Anamirta paniculata* Colebr. (*Cocculus* Wright, *Menispermum Cocculus* Linn., etc.); Order *Menispermaceæ*. This is a large, coarse, woody vine, ascending into the tallest trees, with thick stem and branches, covered with a furrowed, corky, grayish bark. Leaves alternate, heart-shaped, rather thick, and, including the petiole, a foot or more long (thirty centimetres). The petioles, which make about one-third of the length, are thickened and more or less curved, and prehensile at each end. The flowers are small, diœcious, and regular; they grow in long, lax, pendent panicles, often from the older branches. They consist of a calyx of six sepals, surrounded by a few bracts (outer sepals?); no petals. Stamens in the male flowers numerous, united below in a short column, above

Fig. 2881.—Flowering Branch (Male) of Anamirta Cocculus. (Baillon.)

spreading in a dense head of anthers; in the female flowers the stamens are rudimentary. Pistils in the female flowers three, one-celled. One or two of the carpels frequently fail to ripen.

The fruit is a hard and woody drupe, about a centimetre across (two-fifths of an inch), purple when fresh, but grayish brown and slightly shrivelled when dry, of roundish shape, but with a curved axis, as shown by the scar and the base of the style being near together, as well as by its section (see Figs. 2882 and 2883). It bears a remote resemblance to the fruit of the Bay (*Laurus nobilis* Linn.), and to Orange-berries, but the slightest examination is sufficient to distinguish them. Seed globular or reniform, with a slender, curved embryo surrounded by albumen. This vine is a native of India, and elsewhere in Southern Asia, Ceylon, the Malay Islands, etc. It is also cultivated. The fruits (*Cocculus Indicus*, *Coque du Levant*, Codex Med.) are a considerable article of trade in the East, and are said to be employed by fish-catchers. They are also constantly present in the wholesale stores in England and this country, where they are secretly employed in beer, making it more exciting and intoxicating.

This poison does not appear to have been known from a very remote period in Europe (1528, Flückiger, *Pharm. des Pflanzenreiches*), but is probably of very ancient use in parts of Asia. It has never had much employment in medicine, and is scarcely used at all in this country even now.

Composition.—The bitter taste of Cocculus Indicus is entirely due to the seed, which alone contains its principal derivative, *picrotoxin*. This is thus described in the last edition of the Pharmacopœia, where it is for the first time officinal: "Colorless, flexible, shining, prismatic crystals, permanent in the air; odorless, having a very bitter taste and a neutral reaction. Soluble in one hundred and fifty parts of water, and in three parts of alcohol at 15° C. (59° F.); . . . also soluble in acids and in solutions of the alkalies. When heated to about 200° C. (392° F.) the crystals melt, forming a yellow liquid. When heated on platinum foil they char and are finally completely dissipated," etc. About one and a half per cent. can be obtained. The pericarp contains about two per cent. of two tasteless, non-poisonous, crystallizable substances, *menispermin* and *paramenispermin* (the latter doubtful), and the seeds also contain fifteen per cent. of fat, which is used (in India) for candles and similar purposes.

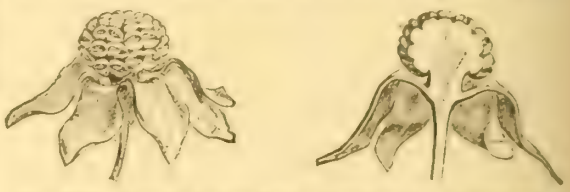

Fig. 2882.—Cocculus Indicus Plant. Staminate flower, whole and in section. (Baillon.)

Action and Use.—As above implied Picrotoxin is a very active poison. Nearly all forms of animal life are affected by it. Fishes, frogs, Guinea-pigs, rabbits succumb to a dose of one or two centigrams, birds are still more sensitive. The principal symptoms are convulsions, both epileptiform and tetanic, stupor, and slowing of the pulse. Fishes poisoned with it perform by spells wriggling and spiral motions; frogs have loss of voluntary motion, convulsions, and a peculiar inflation of the abdomen; dogs suffer salivation, restlessness, vomiting, etc., with nutatory and spiral motions, etc.; in man dizziness, stupor, vomiting, and inflammation of the stomach have occurred. From the above and other observations it is evident that the principal poisoning power of Picrotoxin is directed against the medulla, spinal cord, and cerebellum and cerebrum. It resembles strychnine in part, but adds to the action of that poison its stupefying and heart-slowing power. The original use of Cocculus was to poison fishes. This was done either by distributing it in water or mixing it with bait, when the fish died and rose to the surface. Their meat is said to be dangerous unless they are emptied of the poison promptly after death. It is said to be one of the ingredients of some variety of curare. It is also used occasionally as a vermin (rats, birds, etc.) poison. Its medical employment is exceedingly limited. It has been recommended in paralysis, epilepsy, chorea, hystero-epilepsy, etc., but has not been very successful. As a retarder of the pulse it might be thought of, but we have already several safer remedies for this purpose. It has been used locally in some cutaneous diseases, and as a parasiticide, the latter in ointment, but it has no advantage for this purpose over less dangerous substances. "Convulsions and death have followed its application to the

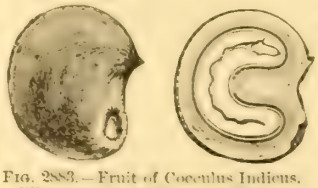

Fig. 2883.—Fruit of Cocculus Indicus. Whole and in section. (Baillon.)

head" (Brunton); from one to two per cent. of Picrotoxin in, say petrolatum, is of sufficient strength for pediculi, etc., if it is desired to use it. Dose, from one to ten milligrams (gr. $\frac{1}{60}$ to gr. $\frac{1}{6}$).

Allied Plants.—See Pareira.

Allied Drugs.—Kerosene oil is an efficient and safe application to the head for lice; so are alcohol, weak solutions of corrosive sublimate, etc., for *pediculi pubis* the old Mercurial Ointment is not excelled. *W. P. Bolles.*

PIGMENTARY METAMORPHOSIS. Syn.: Pigmentary degeneration or infiltration, pigmentation, chromatosis.

Definition.—A pathological process consisting in a deposit of coloring matter in a locality where it is not usually present, or in excessive quantity in regions where pigment normally exists.

Classification.—Basing the classification upon the origin of the coloring matters involved, three kinds of abnormal pigmentation are generally recognized. These are the hæmatogenous, the biliary, and the extraneous—the pigments being severally derived, as the terms indicate, from the blood, from the bile, or from sources foreign to the organism.

Description.—Hæmatogenous pigmentation is believed to be due to a metamorphosis of the coloring matter of the blood. This substance, called hæmatin, exists in the blood in combination with the albuminate, globulin, forming the important oxidizing agent of the red corpuscles, hæmoglobin. Hæmoglobin, when set free by a destruction of the corpuscles, readily dissolves in the plasma, and is therefore readily separated into its component elements and carried off in the circulation. On this solubility depends to a great degree the removal from the tissues of blood-extravasations. A destruction of corpuscles and consequent liberation of hæmatin may, however, take place within the blood-vessels. The coloring matter, while it remains fluid in the tissues, gives to them a more or less uniform yellow or orange color. This is observed in the so-called hæmatogenous jaundice, a phenomenon which is frequently known to accompany the absorption of large extravasations, and is sometimes to be inferred as having taken place in cases of icterus which occur in the absence of the indications of an absorption of bile-pigment. The exact chemical nature of this diffused pigment has not been determined; but it is supposed to be hæmatin or its derivative, although the urobilin of the urine has also been found increased, leading some to infer the presence of true bile-pigment.

The changes of color which are constantly observed in superficial extravasations, especially those of the skin, correspond to changes which occur in the hæmoglobin of the red corpuscles. These have been submitted to careful microscopical examinations, but the results have not been invariably the same. It is asserted, on the one hand, that the coloring matter escapes from the corpuscles and appears first as a diffused pigment, becoming incorporated with the circulating fluids or entering the surrounding fixed tissues. This view has for its basis the fact that there are found, in the immediate vicinity of the extravasation, small, pale, rounded cells, containing a few ill-defined granules, which are supposed to be decolorized red blood-corpuscles. After a few days, a week or more, granules and crystals of a yellowish-red color appear in the outer zone of the extravasation, varying in size from that of a red globule to the merest granule without apparent form. The large crystals are oblique rhombic prisms. Acicular crystals also are sometimes present, occasionally in large numbers, but are frequently entirely absent. These have received the name of hæmatoidin crystals, proposed by Virchow (Fig. 2884). Chemistry thus far has failed to give us a positive analysis of these crystals or a means of distinguishing them from bilirubin, the coloring matter of the bile. We have, in fact, very little useful knowledge of the chemical nature of these coloring matters. By many investigators these substances are believed to be identical, not only because of the similarity which exists between their crystalline forms, but because they present very similar reactions in chloroform solution. This apparent identity receives support from the fact that urobilin (hydrobilirubin), the substance found by Jaffé in the urine of many individuals, especially during fever, has been extracted from both hæmoglobin and bilirubin. Maly, however, who extracted it from bilirubin, is of the opinion that this genetic relation is the only chemical evidence there is of a relationship between these substances. The term hæmatoidin, he thinks, is indicative of only a microscopical picture.

Fig. 2884.—Crystals of Hæmatoidin. (Frey.)

On the other hand, it has been shown by recent investigators that chloroform solutions of crystals supposed to be hæmatoidin do not always exhibit the same chemical reactions. For example, the solution will sometimes become decolorized upon the addition of a dilute alkali, but at other times will exhibit no such change. Bilirubin is thus decolorized by alkalies, but the hæmatoidin of the yolk of an egg and of the corpus luteum (lutein) retains its color.

Langhans, one of the more recent investigators of this subject, maintains that hæmatoidin is formed in movable contractile cells which accumulate in great abundance about the extravasation. These cells have the power of amœboid movement, by which, after from four to six days, they envelop the extravasated red corpuscles, whole or in fragments, sometimes assuming the proportions of giant-cells. After being thus enclosed the corpuscles become smaller, darker in color, and more brilliant, and finally become converted into crystals and granules of hæmatoidin. The contractile cells then undergo fatty degeneration and rupture, discharging the contained pigment into the blood; or they may be carried entire through the lymph- or blood-vessels into remote parts (spleen, liver, kidneys, bone-marrow, brain, etc.), there to give up their pigment.

The experiments of Langhans, in demonstrating the possible formation of pigment by cells, further point to the possibility of its abnormal production in many cases by the cells of the rete Malpighi, the choroid, etc., cells ordinarily associated with the production of coloring matter.

During the absorption of extravasated blood, the deeper portions of the accumulation undergo a condensation, resulting in the formation of a dark brown pigment, composed, according to Kunkel, of a hydrated ferric oxide. Such accumulations of pigment may remain indefinitely in the tissues, or may be removed by again entering the circulation, to be cast off through the excretions.

Every tissue of the body which is supplied with vessels, or lies in proximity to vessels, is liable to hæmatogenous pigmentation, as a result of atrophy, inflammation, hæmorrhage, or other morbid influence. Large or small pigmentary accumulations are therefore of frequent occurrence in various organs, notably in the spleen, liver, kidneys, the medulla of bones, and the brain, and with almost as great frequency in the lungs, heart, lymphatic glands, in all muscles, striated or smooth, in all serous membranes, and in cartilages. The affinity of all tissues for pigment is not the same, however, for cellular structures take up the color much more readily than do the fibrous or homogeneous. The nuclei of cells, however, remain unpigmented, and later often become decolorized, appearing simply as clear spots within the cells. The spleen, liver, kidneys, and bone-marrow are favorite seats for pigmentary deposits, chiefly, in all probability, on account of the character of their circulation. This is true especially of the spleen, the walls of whose blood-vessels permit the ready escape of corpuscles into the surrounding tissues.

Where the destruction of corpuscles is rapid and the amount of pigment entering the circulation is consequently large, as in melanæmia, the blood itself becomes charged with granular matter, and the urine and other secretions frequently become more or less pigmented.

The pigmentation of tissues occurs not only as a result of large extravasations or rapid destruction of corpuscles, but as well from a gradual diapedesis from the vessels of organs in a state of chronic passive hyperæmia, as in the induration of the lungs and liver following valvular disease of the heart. The most frequent cause of extensive pigmentary infiltration is chronic malarial infection. The most familiar examples of it, however, are the numerous discolorations of the skin. These may be circumscribed or diffused.

Circumscribed pigmentations of the skin are congenital or acquired, the former limited to moles and nævi, the latter embracing a variety of discolorations usually described under the name chloasma. Chloasmata are idiopathic or symptomatic. Freckles (lentigines) and sun-spots (ephiledes) are common examples of the former. A more or less general pigmentation of the skin is a symptom of visceral disease, especially of the uterine system in women; and individuals suffering from marasmus often become deeply pigmented. Addison's disease affords another example of symptomatic pigmentation, in which the skin and mucous membranes assume a deep brown or bronze-like hue in connection with disease of the supra-renal bodies. Similar discolorations have been observed in hysterical persons of both sexes, and others as a result of extreme nervous excitation. In the latter the cutaneous secretions have become colored (chromokrinia, stearrhœa). Long continued or often repeated hyperæmia of the skin, as that accompanying the eruptive diseases or the traumata caused by the nails in itching affections, often leads to more or less permanent pigmentation of the affected portions of the integument (traumatic chloasma). As demonstrated by Anstie, the coloring matter of the skin is frequently increased as a result of neuralgia of the nerves of the part; yet a diminution of color has been shown to occur from the same cause.

Such abnormal pigmentations of the skin affect either the rete Malpighi or the corium. The pigment of freckles, that of the discolorations of Addison's disease, chloasma, and melasma (melanosis), as well as the normal coloring matter of the skin, is located in the rete Malpighi, whereas that of the dark mole, that which follows inflammations, blisters, wounds, chronic ulcers, and rarely that of true melanosis, lies in the corium.

The pigmentations of mucous membranes, usually due either to a chronic catarrh or to hæmorrhage, are rarely uniform in their distribution, but generally appear as irregularly distributed spots. The coloring matter is generally located in the corium, rarely in the epithelium of its surface or that lining its glands. The same irregularity characterizes the pigmentation of serous membranes, in which the coloring matter is confined to the connective-tissue cells.

The pigmentary metamorphosis of deeper parts is nowhere better illustrated than in the discolorations of the spleen, liver, kidneys, etc., as a result of prolonged or often repeated malarial infection. The spleen becomes dark brown, almost black, the color being either uniform or mottled. In the acute attacks the organ is usually enlarged, soft, and hyperæmic. Both cellular elements and fibrous stroma are impregnated with granular pigment, as shown by the microscope. In the more chronic forms of the disease, the organ is usually reduced in size and firmer, owing to a sclerosis of the interstitial fibrous tissue, although the organ is frequently larger, often many times larger, than normal. Pigment granules are often found also within the blood-vessels during the activity of the infection.

In the liver the pigmentation may be limited to the interacinous fibrous tissue, sometimes involving also that immediately surrounding the central vein of the hepatic lobule, but in marked cases the granules are usually seen in variable abundance within the lobules. In some cases, too, the pigment appears to lie within the walls of the hepatic artery and the portal vein. According to Frerichs, the liver cells are seldom or never pigmented as a result of malarial toxicæmia, although they frequenly absorb pigment from blood-extravasations in their vicinity. These, however, frequently accompany malarial infection.

Pigmentary changes are more easily recognized in the brain than in any other organ of the body. The cortex sometimes assumes a dark-brown or a blue-black color, the white matter remaining unchanged, except in the most advanced cases. Then it becomes to a slight degree pigmented, the discoloration affecting chiefly the walls of the blood-vessels. The capillaries sometimes appear filled with granular pigment.

The pigmentary phenomena occurring in connection with melanæmia are attributed to a destruction of blood-corpuscles with the formation of hæmatin, especially in the spleen, and its subsequent transfer by the circulating fluids into all parts of the body.

The pigmentary anomalies of other organs, although

Fig. 2885.—Pigmentary Infiltration of the Liver. (Ziegler.)

numerous and of interest, are not of sufficient importance to detain us.

The corpora lutea of the ovary are considered by most authors to be examples of a physiological pigmentary metamorphosis associated with a fatty degeneration, and in all probability due to a diffusion of hæmatin from extravascular accumulations of blood. They have been regarded, however, as examples of a fatty pigmentation.

The pigmentary metamorphosis may be studied also in the lymphathic glands of the vicinity of the extravasation. Into these the red corpuscles pass, many times unaltered, causing them to swell up and assume a dark-red color, with a homogeneous surface on section. Changes much the same as those which have been described as occurring in the vicinity of the extravasation then take place, and after a few weeks, or months at most, there remain only pigment granules and crystals, irregularly distributed throughout the gland. The pigment thus deposited may remain for years, or may be removed by the lymph-current within a comparatively short time, and carried into more remote parts.

Some neoplasms are pigmented from the beginning, others are liable to become so as a secondary change. In the first instance, of which the multiple melanotic sarcoma is a fair example, the growth generally springs from a region which is normally endowed with pigment,

as from the choroid coat of the eye, the skin, etc. The secondary pigmentation of a tumor is due either to the absorption of coloring matter from extravasated blood or to the formation of pigment, as is supposed, within the elements of the growth itself. It is especially common to the sarcoma, but occurs also in the carcinoma, in epithelioma, fibroma, adenoma, and in nearly every other neoplasm. Melanic masses have been described by Cornil and Ranvier as circumscribed accumulations of black pigment in the otherwise normal tissues of the body (see Melanosis, vol. iv., p. 701). The pigment which occurs in melanotic tumors (melanin) is probably not a derivative of hæmoglobin, but the result of a metamorphosis occurring within the elements of the neoplasm. According to Cornil and Ranvier, pigment may thus be formed not only within epithelial and connective-tissue cells, but even within muscular fasciculi. Two forms of melanin have been observed: one, discovered by Virchow, free from iron; the other, discovered by Kunkel, containing iron, but differing spectroscopically from hæmatin, bilirubin, and hydrobilirubin.

Biliary Pigmentation includes all discolorations of the tissues and fluids of the body by the coloring matters of the bile. Bilirubin is the pigment to which the staining is for the most part due, but, as a rule, all the biliary coloring matters are carried to the tissues. The color is generally diffused throughout the tissues, but in very intense jaundice, irregular, glistening, ruby-red crystals of bilirubin are sometimes found in the liver. Tissues thus stained acquire a yellow color, at first pale, later becoming darker, or assuming an olive or ashen-green tint. The discoloration begins in the liver; here, too, it reaches its greatest intensity, being due to direct absorption, independent of the circulation. From the liver the pigment is carried by the blood to nearly every tissue of the body, although it is not appropriated with the same rapidity or to the same extent by all. The heart and blood-vessels soon become stained by direct contact with the coloring matter which has entered the blood. All epithelia are early susceptible to the discoloration (the nuclei usually remaining less pigmented), and the bones and teeth take up a yellow color. Neoplasms usually become jaundiced. The central and peripheral nervous systems resist the pigment until very late, and they become but faintly, if at all, discolored. Nearly all fluids, normal or pathological—the blood, urine, sweat, milk, exudates, transudates, become stained; the saliva, tears, and mucus are probably never discolored. The kidneys, by which the bile is for the most part eliminated from the system, become almost or quite as deeply jaundiced as does the liver itself. When jaundice affects for a long time a pregnant woman, the fœtus usually becomes discolored.

Biliary pigmentation of this kind is due almost invariably to some form of mechanical obstruction of the flow of bile in some part of its course from the hepatic lobules to the intestine. The various influences which may lead to this result have been admirably arranged in tabular form in the article on Jaundice, to which the reader is referred (see Jaundice, vol. iv. p. 237).

Extraneous Pigmentation is the term applied to all discolorations of the tissues by the incorporation within them of foreign substances optically distinguishable from them, and capable of remaining for a long time unchanged by the fluids of the body. The number of substances capable of thus entering the organism is great; the most frequent avenues of their entrance are surface wounds, the respiratory passages, and the alimentary canal.

Tattooing is the most familiar example of the first class. In this barbarous practice, the skin is first wounded by puncture or scraping, and an insoluble granular pigment of the desired color is thoroughly rubbed in. A large part of the pigment thus introduced remains permanently at the place of entrance; but a part of it is carried to the neighboring lymphatics, where it becomes permanently incorporated.

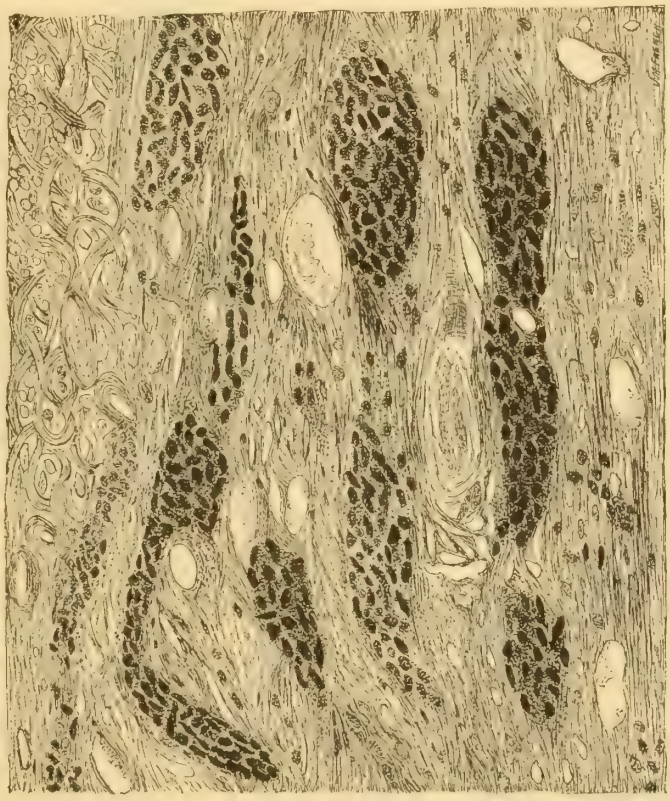

Fig. 2886.—Pigmentation of the Bronchial Glands, chiefly by Extraneous Coloring Matter.

Pigmentation of the lungs through the inhalation of coal-dust, soot, particles of iron, and other impurities of the atmosphere, to a variable degree, is almost universal. A considerable part of the carbon penetrates the delicate walls of the pulmonary alveoli and becomes embedded in the fibrous tissue. A part, however, is usually carried to the pulmonary and bronchial lymphatics (Fig. 2886). Owing to the irritation and the laceration of the tissues by the penetration of these small, sharp-edged particles, and the consequent escape of blood, in small but repeated quantities, it is usual to find, in connection with this condition of the lungs and glands, a greater or less amount of hæmatogenous pigmentation. This may sometimes be recognized by the presence in some cells of a diffused yellowish discoloration.

Argyria is a form of extraneous pigmentation due to the continued ingestion of the salts of silver, especially of the nitrate. The discoloration, fortunately now not often seen, affects the skin, the mucous membranes, and some of the deep-seated tissues, notably the kidneys. The silver is supposed to be absorbed into the system as an albuminate, undergoing reduction to the oxide after it reaches the tissues; or, as some think, it enters the system after it has become reduced in the intestinal canal. A similar, though less pronounced, discoloration of the skin follows the prolonged ingestion of arsenic. The blue line in the gums indicative of saturnism is also an example of extraneous pigmentation.

Finally, certain micro-organisms, by virtue of their own refractive powers, or by reason of changes which they produce, cause alterations of color in the tissues which they invade.

This is well illustrated in the discolorations of pityria-

sis versicolor, favus, and in certain affections of the mucous membranes.

Results.—Aside from the very obvious changes of color which are caused by the pigmentary metamorphosis, the results of the entrance of abnormal coloring matters into the tissues are various, but in most instances of little importance. The latter is true particularly of the hæmatogenous pigmentations. The deposit of a considerable amount of pigment in an organ, especially if it be pigment absorbed from an extravasation of blood, does not, as a rule, occasion any appreciable derangement of function. Important regions of the central nervous system have been found markedly pigmented, in cases in which no functional disorder had existed during life. There are probably no symptoms which belong properly to the presence of blood-pigment in the tissues during melanæmia, nor are the symptoms accompanying jaundice due solely to the presence of the bile-coloring matters.

In neoplasms, however, the result, according to most authors, is different, the mere presence of pigment being supposed to add malignancy to the growth.

Grave lesions accompany also the extraneous pigmentation, especially that of the lungs. Owing to the irritation caused by the foreign matter, coal, iron, etc., hyperplasia of the interstitial fibrous tissue is produced, resulting in a marked induration of the lung (miner's or knife-grinder's phthisis), associated with which is always a catarrhal inflammation of the bronchial tubes and pulmonary vesicles. The effects upon the system of silver, lead, and arsenic are wholly independent of their chromatic properties. *James M. French.*

PINK, CARNATION (*Œillet rouge*, Codex Med.). This favorite flower, *Dianthus Caryophyllus ruber* Linn.; Order, *Caryophyllaceæ*, is a native of Europe, but cultivated for ornament both there and here. Its deliciously sweet-scented petals, plucked just as they are expanding, and rapidly dried, are employed abroad to make a syrup of pleasant color and taste, but possessing no medicinal properties. It may be used as a vehicle.

Allied Plants.—The genus is a large one, and comprises many species, with small and inconspicuous flowers, and not a few with large and handsome ones. Of the latter, a number are in cultivation as pinks of various sorts, "Sweet Williams," "Pheasant's Eyes," etc. Other genera furnish numerous common weeds—Chickweeds, Sandworts, Catchflies, and others, and a few flowers. *Saponaria officinalis* Linn., Soapwort, gave its name to the peculiar active principle it contains, *saponin;* see Soap Bark. The order, as a whole, is non-poisonous.
W. P. Bolles.

PINKROOT (*Spigelia*, U. S. Ph.). The root of *Spigelia Marilandica* Linn.; Order, *Loganiaceæ*. This is a perennial herb, with a horizontal, twisted rhizome, and several erect, simple, somewhat quadrangular stems. Leaves opposite, sessile, ovate-lanceolate, smooth. Inflorescence terminal in a one-sided (scorproid) spike, of half a dozen or more showy flowers. Calyx small, five-parted; corolla tubular, trumpet-shaped, with five acute, spreading lobes; bright scarlet outside, bright yellow within. Stamens five, inserted on the corolla; pistil single; ovary two-celled, several-seeded, superior. Pinkroot is a native of the Middle and Southern States, where large quantities are annually collected, more for domestic than professional demand. It is also cultivated in Europe as a garden flower. Its medical properties have been known for upward of a century.

The description of the Pharmacopœia is as follows: "Rhizome two inches (5 centimetres) or more long, about one-eighth of an inch (3 millimetres) thick, horizontal, bent, somewhat branched, on the upper side with cup-shaped scars; on the lower side, with numerous thin, brittle rootlets, about four inches (10 centimetres) long; dark, purplish-brown, somewhat aromatic, sweetish, and bitter." Pinkroot is carelessly gathered and often mixed with other roots. The roots of *Phlox carolina* are sometimes substituted for it.

But little is known of the constituents of this root, although it is not devoid of activity. *Starch, resin*, traces of *oil*, and other ordinary plant substances do not explain its value. There are acrid and bitter extractives not yet isolated.

Action and Use.—In overdoses Spigelia seems to be a narcotic poison, and may be dangerous; quickening of the pulse, dryness of the throat, flushing and heat of the skin, uneasiness, and delirium are said to have followed its use. It is also spoken of as a "tonic and alterative," a phrase that probably does not mean much. There is little doubt that, in the cases where it is most employed—of *lumbrici* or round worms—it is of considerable value.

Fig. 2867.—Pinkroot. *a*, Twig with blossom; *b*, grain centre; *c*, section of flower; *d*, section of grain; *e*, fruit. (Baillon.)

A fluid extract (*Extractum Spigeliæ Fluidum*, U. S. Ph.) is a good preparation, and the one generally prescribed. It is frequently combined with Senna or some other cathartic. Dose for an adult, ten or fifteen grams (℥ ss.); for small children, from thirty to sixty or eighty drops.

Allied Plants.—Another *Spigelia*, *S. anthelmintica*, growing in South America and cultivated in the West Indies, as its name implies, has similar properties and uses. It is unknown here. For the order, see Nux Vomica.

Allied Drugs.—Santonin, Male Fern, Koosso, Pumpkin Seed, and Pomegranate Bark, etc., are used for the same purposes, with success.
W. P. Bolles.

PIPSISSEWA (*Chimaphila* U. S. Ph.), *Chimaphila umbellata* Nutt. (*C. corymbosa* Pursh.); Order, *Ericaceæ*, is an upright, woody little plant, known in New England as Prince's Pine, sometimes sharing the name Wintergreen with *Gaultheria*. It has running stolons or suckers, and short, woody, upright shrubby stems, fifteen to thirty centimetres high, bearing from one to three clusters of oblanceolate, evergreen leaves. Flowers, several in a long stemmed, terminal corymb, regular, perfect. Sepals five, small, blunt. Petals five, concave, rounded, yellowish-pink, forming a saucer-shaped corolla. Stamens ten; ovary, five-celled, many-ovuled. It is to be found wild in cool, dry woods of both hemispheres. Chimaphila leaves are easily recognized. They are very smooth and stiff when dry, from four to six centimetres long; oblanceolate or wedge-shaped, rounded at the apex, nar-

rowed at the base, sharply serrate in the upper part of the border. Taste astringent and bitterish, odor slight.

The constituents of Chimaphila are probably similar to those of Pyrola or *Uva Ursi*—*Tannin*, *Arbutin*, a little *oil*, etc., and the peculiar substance *Chimaphilin*, but its analysis is not at present wholly complete. It is put to

Fig. 2888.—Pipsissewa. Flower of Pirola Rotundifolia. (Baillon.)

about the same uses as *Uva Ursi*, as a tonic and diuretic in chronic vesical catarrh and related diseases; it is also given sometimes in cardiac and renal dropsies.

It may be administered in infusion or decoction: half a pint of a ten per cent. infusion may be taken through the day, or, if preferred, the officinal Fluid Extract (*Extractum Chimaphilæ Fluidum* U. S. Ph.) may be given in doses of five or six grams, three or four times a day.

Allied Plants and Drugs.—See Uva Ursi, etc.

W. P. Bolles.

PISTACHE (Codex Med.) Pistacia Nuts. The seeds of *Pistacia vera* Linn.; Order, *Anacardiaceæ*, a graceful, fragrant tree, with pinnate leaves, growing naturally in Syria and Persia, and cultivated in Greece, the South of France, and, indeed, in the Mediterranean region generally. Its fruit is a sort of dry drupe, like the almond, about as large as a large olive. It splits easily when ripe, and liberates a long, flattened, brownish seed, containing a large, oily, pleasant-tasting, green embryo, which is edible.

This product has no medicinal properties, but is extensively used as an article of food or flavoring by confectioners, in *bon-bons* and ices. An emulsion may be made by pounding the seeds with sugar and water, after the manner employed with almonds. This can be used as a pleasant vehicle for more active substances.

Allied Plants.—Chian Turpentine and Mastic are obtained from other species of Pistacia, Cashew Nuts, Poison Ivy, Japanese Lacquer, and Chinese Galls from other genera in the order.

Allied Drugs.—See Almonds. *W. P. Bolles.*

PITCH, BLACK. Common Pitch; see Turpentine.

PITCH, BURGUNDY (*Pix Burgundica*, U. S. Ph., Br. Ph.; *Poix de Bourgogne*, *Poix des Vosges*, *Poix jaune*, Codex Med.). This opaque resin is nominally, and properly, obtained in Europe from the Norway Spruce, *Pinus Picea* Du Roi (*Pinus excelsa* L. K., *Pinus Abies* Linn., *Abies excelsa* D. C.), order *Coniferæ*, a magnificent evergreen with a pyramidal head reaching forty metres or more in height, and having branches even down to the very ground. Its cones are large and pendant, its foliage close, and of a brilliant green color. It is an abundant forest tree of Northern Europe and Asia, and a frequent ornamental one here.

Burgundy Pitch is not an empyreumatic product like common black pitch, but a turpentine which has been exposed to hot water or steam, and has in consequence taken up enough of it to become opaque. It is collected by making rather deep incisions in the trunks of the trees, scraping off the resinous sap that flows out, and boiling it in water and straining it through cloths. The collection is carried on in Austria and Switzerland, but not to a very great extent, and is diminishing. In the place of this genuine article, the turpentine of other European pines, prepared in the same way, is frequently substituted, and is sanctioned in most countries; and, besides this, an entirely spurious preparation of common American rosin, mixed with oil or fat and water, is the common (false) Burgundy Pitch of the market. That sold in this country is said to be almost never genuine. The following description of the genuine will not with certainty exclude some of the adulterations: "Hard, yet gradually taking the form of the vessel in which it is kept; brittle, with a shining, conchoidal fracture, opaque or translucent, reddish-brown or grayish-brown, aromatic and somewhat empyreumatic; not bitter. It is almost entirely soluble in glacial acetic acid."

The principal portion of this substance—eighty per cent. or more—is *resin*, amorphous and opaque until the water is evaporated off, then clear; from three to five per cent. of *essential oils* are also present, and from five to ten of *water*.

It is a mildly stimulating substance when applied to the skin; taken internally it has the properties of common rosin or Turpentine, etc. (see Turpentine); stimulating in small doses, irritating in large ones; but it is milder in its taste and action than common turpentine. Its very limited medicinal use is almost entirely confined to its presence in a few plasters, of which the following are officinal here: Burgundy Pitch Plaster (*Emplastrum Picis Burgundicæ*, U. S. Ph.). Burgundy Pitch, ninety parts; yellow wax ten parts, melted together and strained. It may be used as it is, or as the basis for other more active medicaments. The Pitch Plaster with Cantharides is more stimulating; it consists of: Burgundy Pitch, ninety-two parts; Cerate of Cantharides (thirty-five per cent.), eight parts, melted together after straining the cantharidal cerate through a very fine strainer.

Allied Plants and Drugs.—See Turpentine.

W. P. Bolles.

PITCH, HEMLOCK (*Pix canadensis*, U. S. Ph.). This is a product of the Hemlock Spruce, *Pinus canadensis* Linn. (*Abies canadensis* Michaux); Order, *Coniferæ*, collected and prepared in much the same way as the preceding. It appears to be often boiled more, and is frequently very dark, almost black in consequence. It is described as follows: "Hard, yet gradually taking the form of the vessel in which it is kept; brittle, with a shining, conchoidal fracture, opaque or translucent; dark reddish-brown; having a weak, somewhat terebinthinate odor." Canada Pitch has essentially the same properties as the preceding, and is used (if ever) for the same purposes. A plaster is made of it in exactly the same way as the Burgundy Pitch Plaster (see above).

Allied Plants, etc.—See Turpentine.

W. P. Bolles.

PITYRIASIS. A term formerly applied to a number of affections of the skin whose chief characteristic is scaliness (πίτυρον, bran). The greater number of cases of so-called pityriasis are merely eczema squamosum. *P. versicolor* is now known as *tinea versicolor*. Three affections only are in general included under this head by modern dermatologists. These are *P. simplex*, sometimes miscalled by the Germans "seborrhœa sicca," *P. maculata et circinata* (also called *P. rosea*), and *P. rubra*. These will now, as they are entirely distinct affections, be described under separate heads.

Pityriasis Simplex is an inflammatory or hypertrophic affection of the skin, characterized by the appearance of small circumscribed or large diffused areas of scaliness without infiltration into the skin. The scales of pityriasis are small, not imbricated like those of psoriasis, and less adherent, being readily removed by the slightest friction, but quickly replaced by a fresh crop. The patches of eruption vary in size and may occur upon any portion of the surface, although they are most frequently encountered upon the scalp, face, and upper part of the body, and especially the hairy parts, including the scrotum and genito-crural region. They are rarely found below this point upon the lower extremities. Occurring upon the scalp, the disease forms one variety of the affection popularly known as "dandriff." Here a slight mingling of sebum sometimes gives the scales a certain oiliness. The affection is also frequent upon the eyebrows

and on the bearded lip and chin. It is occasionally observed in the centre of the sternum and between the shoulders. Pityriasis simplex is commonly without sensation, but occasionally gives rise to a certain amount of itching. Though a slight affection, it is apt to run a chronic course, and when occurring in the scalp of young persons, is not infrequently the precursor of premature baldness.

Pityriasis of the scalp may be confounded with squamous eczema, psoriasis, and some forms of seborrhœa, into which latter disease it sometimes merges. In eczema, however, the scalp is redder and more infiltrated, the scales are more scanty, and there is almost always either a history of weeping and oozing, or some characteristic lesions of eczema elsewhere. In psoriasis the scales are apt to have a yellowish tinge; the disease prevails more around the edge of the hairy scalp, and some characteristic patch of psoriasis is almost always to be found elsewhere upon the skin. In seborrhœa the oily element is prominent; the scales are matted together, yellowish, and greasy, so that if they are laid upon paper a grease spot soon forms.

The treatment of pityriasis simplex of the scalp is chiefly local. The scalp should be thoroughly cleansed by shampooing with soap and water, or if the scales are abundant, by means of Hebra's "spiritus saponis kalinus." This soapy tincture is to be mixed with water and used as a shampoo. A teaspoonful in a tablespoonful or more of water, rubbed into the scalp, with the addition of more water, will quickly work up into a fine lather that will cleanse the scalp effectually. This is washed out with pure water, and as soon as the scalp is dried, one of the following applications should be made. If the hair is thick the following is preferable: ℞. Acid. carbolic., Gm. 5 (ʒ j.); alcoholis, Gm. 48 (ʒ jss.); glycerinæ, Gm. 10 (ʒ ijss.); olei limonis, Gm. 6 (ʒ jss.). M. A few drops of this mixture should be dropped here and there over the surface by means of a Barnes' dropper such as is used for eye-drops, and then well rubbed into the scalp with a dry brush. Another good application is the following: ℞. Acid. salicylic., Gm. 2 (ʒ ss.); acid. carbolic., Gm. 1 (gr. xv.); olei ricini, Gm. 4 (ʒ j.); alcoholis q. s. ad Gm. 32 (f ʒ j.). M.

The soap-wash may be used once a week or so, according to the rapidity with which the scales accumulate; but the oily applications should be made once in twenty-four hours, until the scalp is restored to a healthy condition.

The treatment of pityriasis simplex occurring on other portions of the surface, both hairy and non-hairy, is somewhat different. Here ointments may be used. An ointment of sulphur, one part, to eight parts of vaseline, is usually beneficial, or a weak mercurial ointment may be employed. When the skin grows greasy castile soap may be used to wash away the excess of ointment.

Internal treatment is sometimes, but not by any means always, demanded. Tonics, and particularly iron, will be found useful. If there be constipation, with a tendency to anæmia—a not very uncommon combination in young persons suffering from pityriasis—the following will be found efficient: ℞. Magnesii sulphat., Gm. 32 (ʒ j.); ferri sulphat., Gm. 4 (ʒ j.); sodii chloridi, Gm. 4 (ʒ j.); acid. sulphuric. dil., Gm. 4 (f ʒ j.); infus. quassiæ, ad Gm. 128 (f ʒ iv.) M. Sig.: Tablespoonful in a tumbler of water before breakfast.

Pityriasis Maculata et Circinata, sometimes called *pityriasis rosea* is an inflammatory disease of a mild type, occupying chiefly the trunk, more particularly the subclavicular, lateral thoracic, and scapular regions. It is characterized by discrete or confluent macular or slightly raised maculo-papular lesions, usually the former, varying in size from that of a pin-head to that of a silver half-dollar. They are roundish, circular, or ovalish, sharply circumscribed, superficially seated, and are either on a level with the surrounding skin, or slightly elevated; or, on the other hand, they are depressed so that their border often presents the appearance of a ring. In color they are generally rosy or pale red, with, later, a more or less yellowish or tawny tint; in other cases the red is deeper and the coloring mottled. The surface of the patches is always dry and more or less scaly, the desquamation being furfuraceous and, as a rule, scanty, similar to that of tinea versicolor, and tinea circinata. It is usually more pronounced about the borders of the lesions, which incline to heal in the centre and spread on the periphery. The skin is but little thickened, and sometimes feels almost normal when taken between the fingers. The subjective symptoms are variable; in some cases there is decided itching, especially noticeable when the patient is overheated; while in other instances the individual is scarcely made aware of the existence of the eruption.

The above description, from Duhring, gives a fair average portrait of the affection, but must be accepted with many modifications, both as to color and size of lesions, amount of pruritus, etc., which vary greatly in different cases. In Duhring's experience the course of the disease is quite uniform as to duration, the lesions usually lasting from one to three months, when spontaneous involution sets in, recovery taking place with increased desquamation and pigmentation, within a fortnight or a month. In the writer's experience this average is often broken by cases running a rapid course, and amenable to treatment, and by others lasting a much longer time without changing materially. The onset of the disease may be sudden or gradual, new lesions appearing from day to day or from week to week. They are in many cases numerous and situated close to one another, in which case, as they enlarge, they incline to coalesce, forming variously sized and shaped—often large—macular or circinate patches. Thus, as in tinea versicolor, the whole chest or the neck may be invaded by a continuous or interrupted patch.

Pityriasis maculata et circinata may be confounded with tinea circinata, or with tinea versicolor, to both of which it at times bears a striking resemblance; also with tinea versicolor, seborrhœa, or pityriasis corporis, lichen ruber, psoriasis, and syphilis. It has the general appearance and the course of a vegetable parasitic affection, but no specific fungus has as yet been demonstrated in connection with the lesions.

The disease tends in most cases to spontaneous recovery, but in many cases much patience is required to arrive at that conclusion. Commonly, it is better to use such remedies as may be suggested by the obvious aspects of the case, rather than pursue a purely expectant course.

Frequent bathing, followed by the application of the following ointment, has proved beneficial in the writer's hands: ℞. Acid. salicylic., Gm. 4 (ʒ j.); ung. petrolii, Gm. 32 (ʒ j.).

Pityriasis Rubra.—In the article on Dermatitis Exfoliativa, in this work, reference was made to Pityriasis Rubra as another form of disease. Further investigation, however, has demonstrated that the affections are identical. Reference may therefore be made to the article mentioned.

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Arthur Van Harlingen.

PLACENTA, ANATOMY OF. The human placenta (*Mutterkuchen*) is a disk of tissue to which the umbilical cord of the child is attached by its distal end. As a result of normal labor, the amnion and chorion, by which the *fœtus in utero* is surrounded, are ruptured; the child is then expelled, but by means of the long umbilical cord remains attached to the uterus; after an interval the

placenta, with which the cord retains its connection, is loosened from the uterine wall and expelled together with the fœtal envelopes and portions of the decidual membrane (uterine mucosa) of the mother; the parts thus thrown off secondarily constitute the so-called *after-birth* of obstetricians.

The placenta at full term, as thus obtained by natural expulsion, is a moist mass, containing a great deal of blood; spongy in texture; about seven inches in diameter, but very variable in size, being roughly proportionate to the bulk of the child; usually oval, sometimes round, but not infrequently irregular in shape. One surface is smooth and covered by a pellucid membrane (the amnion), and reddish-gray in color; to this surface the umbilical cord is attached, and it shows the arteries and veins branching out irregularly from the cord over the surface of the placenta (Fig. 2889). The opposite surface is rough, lacerated, and is usually covered irregularly with more or less blood, which is often dark and clotted. When the blood is removed, the surface is seen to be crossed by a system of grooves which divide the placental tissue into irregular areas, each perhaps an inch or so in diameter; these areas are called the cotyledons. The placenta is about twenty-five or thirty millimetres thick, but thins out rapidly at the edges, and its tissue passes over without a break into thin fœtal membranes, which accordingly spring, as it were, from the margin of the placenta.

When *in situ*, the placenta is fastened to the walls of the uterus by its rough or cotyledonary surface; its smooth, amniotic surface faces the cavity in which the fœtus lies.

A more detailed examination of the gross appearances of a placenta discharged at term, leads to the following additional observations. The color is a reddish or purplish-gray, varying in tint according to the condition of the blood, and mottled between the divaricating blood-vessels by patches and networks of pale yellowish or flesh color. The light pattern is produced by the tissue of the villi shining through the membrane of the chorion. These appearances are less distinct when the placenta, as is usually the case, is covered by the thin amnion. The amnion, however, is very easily detached as far as the insertion of the umbilical cord, but from the latter it cannot be peeled off. The blood-vessels run out in all directions from the end of the cord; each vessel produces a ridge upon the placental surface, so that its course is readily followed. The arteries and veins are more easily distinguished after double injection,* as is shown in Fig. 2889. The two kinds of vessels do not run together; the arteries lie nearer the surface, the veins deeper; the arteries fork repeatedly, until they are represented only by small branches and fine vessels; some of the small branches disappear quite suddenly by dipping down into the deeper-lying tissue in order to pass into the villi. The veins (Fig. 2889) are considerably larger than the arteries; they branch in a similar manner, but some of the trunks disappear from the surface more abruptly than is the case with the arteries. There is the greatest possible variability in the vessels of the placenta; I have never seen two placentæ with vessels alike. So far as I have observed, the insertion of the cord is always obviously eccentric; the degree of eccentricity is variable, and is easily seen to be related to the distribution of the vessels. The insertion of the cord may even be entirely outside the placenta, which yet, as B. S. Schultze has shown, may otherwise be normally developed. Such insertions are called velamentous. The usual type is shown in Fig. 2889. The arteries come down together from the cord; they usually, but not always, anastomose by a short transverse vessel, which lies about half an inch above the surface of the placenta; it could not be shown in Fig. 2889. I have never noticed any arterial or venous anastomoses on the surface of the placenta. The arteries then spread out in a manner which may be described as roughly symmetrical. The vein partially follows the course of the arteries. When the cord is inserted near the margin, the symmetry of the placental vessels is greater; when the insertion is nearer the centre, the symmetry is less than in Fig. 2889.

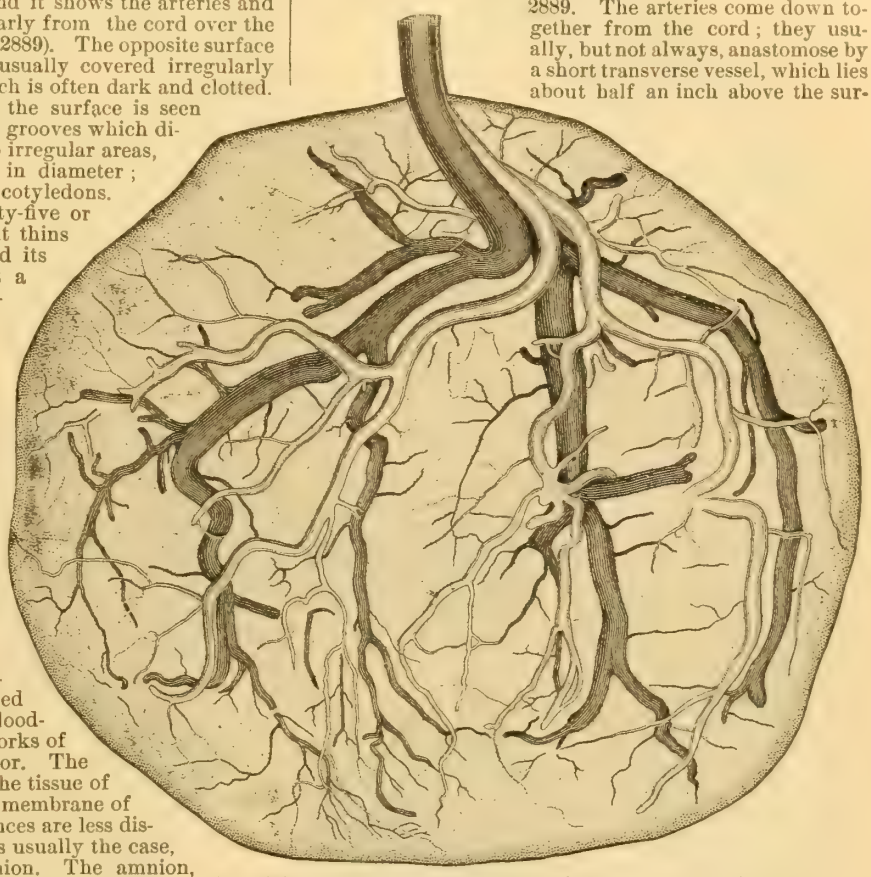

Fig. 2889.—Placenta at Full Term, doubly injected by Dr. H. P. Quincy, to show the distribution of the vessels upon the surface.

The reverse or uterine surface of the placenta is rough, and divided into numerous rounded, oval, or angular portions, termed lobes or cotyledons,* as stated above. These vary from half an inch to an inch and a half in diameter. The whole of this surface consists of a thin, soft, somewhat leathery investment of deciduous membrane, which dips down in various parts to form the grooves that separate the cotyledons from each other. This layer is a portion of the decidua which, as long as

* For double injections Gage's starch mass is convenient. The stock-mixture contains 4 vols. dry powdered starch: 4 vols. of a 2.5 per cent. solution of chloral hydrate: and 1 vol. of ninety-five per cent. alcohol. To make a white mass add 1 vol. of starch to the stock solution, that is, to 9 parts of the stock, add 1 of starch. To make a blue mass, add 1 part in bulk of dry ultramarine to 9 parts of the stock. Before injecting, force out of the placenta as much blood as possible by mechanical means: then wash out the vessels with a 0.6 per cent. salt solution, first through the arteries, then through the veins. The white mass may be thrown into the arteries: the blue mass into the veins. The placenta should then be washed in running water for at least twenty-four hours to extract the blood. The injected specimens may be preserved in Wickersheimer's fluid, which will need to be changed at least twice.

* The division of the placenta into cotyledons is not primary, but, on the contrary, is not developed until the fourth or fifth month.

the parts are *in situ*, constitutes the boundary between the placenta and the muscular substance of the uterus, but which at the time of labor becomes split asunder, so that, while a portion is carried off along with the pla-

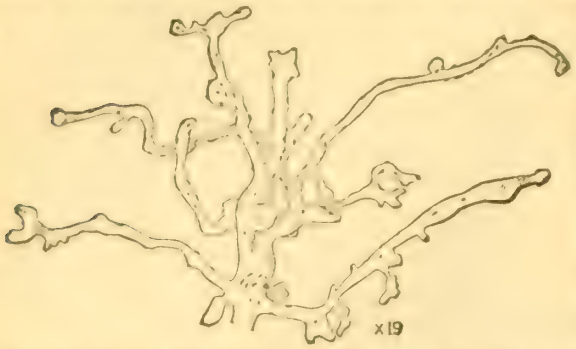

Fig. 2889.—Terminal Vein of a Placenta at Full Term. The little spots represent the proliferation islands of the covering epithelium.

centa and constitutes its external membrane, the rest remains attached to the inner surface of the uterus.*

If a placenta is cut through, it is found to consist of a spongy mass containing a large quantity of blood, and bounded by two membranes, each less than a millimetre thick; the upper one is the chorion covered by the still thinner amnion, and greatly thickened where the vessels lie in it; the lower one is the decidual tissue together with the ends of the villi imbedded in it (*cf.* Decidua, vol. ii., especially p. 392, and Fig. 804); it represents only a portion of the decidua, the other portion has remained upon the uterine wall. The spongy mass is found, upon examination, to consist of an immense number of tufts of fine rods of tissue, which are irregularly cylindrical in shape. Further examination shows that they are twigs (Fig. 2890), with rounded ends, and springing from little branchlets, which in their turn arise from branches, and so on, until a large main stem is found, which starts from the chorion. This branching system is richly supplied with blood from the fœtal vessels on the surface of the placenta. The villi are interwoven so that the twigs of one branch are interlaced with those of another, and apparently separate twigs may grow together and their vessels anastomose, but on this point I am unable to speak positively. The villous twigs next the surface of the decidua penetrate that tissue a slight distance. The intervillous spaces are filled, or nearly so, with blood; they form a complex system of channels. The intervillous blood, as we know from the researches of Farre, Turner, and Waldeyer, is maternal. Farre says, in his article in Todd's Cyclopædia,[49] p. 716, in reference to the placental decidua: "Numerous valve-like apertures are observed upon all parts of the surface; they are the orifices of the veins, which have been torn off from the uterus. A probe passed into any one of these, after taking an oblique direction, enters at once into the placental substance. Small arteries, about half an inch in length, are also everywhere observed imbedded in this layer. After making several sharp, spiral turns, they likewise suddenly open into the placenta;" and on p. 719 he adds: "These venous orifices occupy three situations. The first and most numerous are scattered over the inner side of the general layer of decidua, which constitutes the upper boundary of the placenta; the second form openings upon the sides of the decidual prolongations or dissepiments, which separate the lobes from each other; while the third lead directly into the interrupted channel in the margin, termed the circular sinus." The circular sinus (Fig. 2891, *Si*) is merely a space at the edge of the placenta, which is left comparatively free from villi. It is not a continuous channel, but is interrupted here and there.

To study the histology of the placenta, sections are best made after imbedding the organ in celloidine. Fig. 2891 represents parts of a section of a placenta at term, from which the amnion was removed. Fig. 2891, A, represents the placental margin magnified thirteen diameters; B, a portion of the decidua near *b* in A, but more highly magnified. The chorion, *Cho*, and decidua, *D*, are in immediate contact at the left of the figure, that is, outside the placenta, though remnants of a few aborted villi, *vi*, are still plainly recognizable; but they are found only close about the placenta. At the margin of the placenta and in its neighborhood, the chorion and decidua are not clearly delineated, but, on the contrary, the decidual cells find here an opportunity to penetrate the chorionic membrane. The placental chorion exhibits its characteristic stratification a short distance within the margin. I have found, however, that the distinctness of that stratification varies considerably, not only in different placentæ, but also in different parts of the same placenta. The decidua, *D*, outside the placenta is very thick, but at the edge it begins to thin out, and, as it

Fig. 2891.—Placenta at Full Term. A, vertical section through the margin; D, decidua; *vi*, aborted villi outside the placenta; *Cho*, chorion; *Si*, sinus; *Vi*, placental villi; *Fib*, fibrine. B, portion of A more magnified, to show the decidual tissue near *b*; *v*, blood-vessel; *d*, *d'*, decidual cells; *d*, with one nucleus; *d'*, with several nuclei.

* This paragraph is taken almost verbatim from Farre.

passes over the under side of the placenta, rapidly becomes so much reduced as to be even less in thickness than the chorion, *Cho.* The decidua is characterized by an immense number of large decidual cells, not scattered about as in Fig. 804, vol. ii., but densely packed, Fig. 2891, B; the cells are irregularly oval in outline, clear,

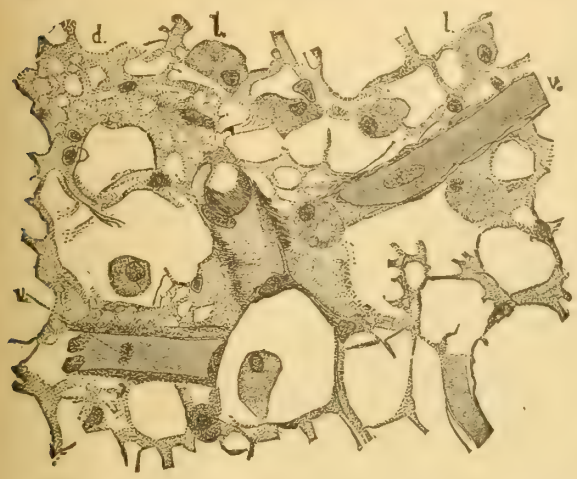

Fig. 2892.—Adenoid Tissue of a Villus, from a Placenta of four Months. *l*, *l*, Leucocytes; *v*, *v*, capillary blood-vessels; *d*, finer meshwork from near a capillary.

somewhat granular, and have usually a single nucleus; a few are larger, more granular, and multinucleate.

At the edge of the placenta the chorion and decidua separate; where they first part there are very few villi (Fig. 2891, *Si*), but elsewhere the room between them is occupied by innumerable branches of villi, *Vi*, *Vi*, with narrow spaces between them for the blood; the sections of the villi are of all sizes and shapes; they all contain blood-vessels, but only the larger ones can be distinguished with the magnification of Fig. 2891, A, where they have been made as distinct as possible by being drawn black. The spaces between the villi have been left white, the blood which partially filled them not being represented.

The histology of the chorion requires a few words. Since writing the article on the Chorion (*ante*, vol. ii., p.

Fig. 2893.—Cross Section of a Villus, from a Placenta of Seven Months; three blood-vessels are shown. *a*, *a*, Thickenings of the epithelium; *f*, a thickening transformed into canalized fibrine.

143), I have accumulated observations which explain more fully the history of its layers. We will speak, first, of the membrane proper; second, of the villi. As stated in vol. ii., p. 146, the chorionic membrane develops four layers: two, the stroma and the fibrillar layer, are derived from the connective tissue, or mesodermic layer; the other two, the cellular and the fibrine layers, I have since ascertained to be derived from the epithelium. The epithelium (ectoderm) of the chorion develops numerous centres of cell multiplication, which result in outgrowths that become the branches of the villi (see

Fig. 2894.—Portion of an Injected Villus from a Placenta of about Five Months; magnified.

vol. ii., p. 145), but after the third month many of these centres of growth (proliferation islands) follow a different career of development; they produce merely each a local thickening of the epithelium, such as is readily found in the placenta at term by picking out a small bunch of terminal villi and staining it with hæmatoxylon; the thickenings appear as scattered dots (Fig. 2890). The little thickenings may grow and spread so that adjacent ones fuse, thus constituting a thickened patch of epithelium. Over the chorionic membrane these patches become quite large, and the cells undergo a metamorphosis by which the patch is converted into what is known as the cellular layer. The cellular layer may then undergo a hyaline degeneration, which gives rise to the fibrine layer; the degeneration commences in the superficial part of the cellular layer, so that in some portions there may be two distinct strata; on the other hand, the degeneration may progress until the whole of the cellular layer is replaced by fibrine.

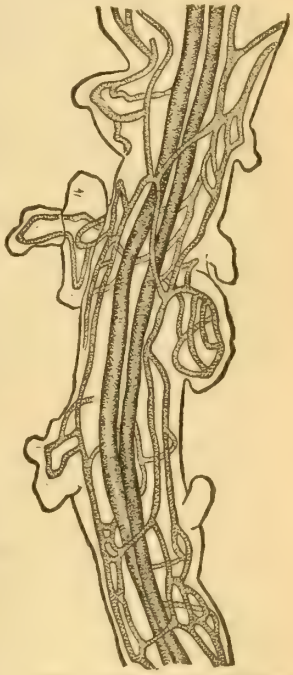

Fig. 2895.—Portion of a Small Villous Stem from an Injected Placenta of about Five Months; magnified.

In the villi the mesoderm exists in two principal forms: 1, adenoid tissue; 2, fibre-cell tissue around the blood-vessels. The adenoid tissue (Fig. 2892) may be described as the proper tissue of the villi. It consists of a network of protoplasmic threads, which start from nucleated masses (cells). There are many large meshes which are partly occupied by the scattered leucocytes, *l*, *l*, present in very large numbers. About the capillaries the network is more finely spun (Fig. 2892, *d*). This tissue is obviously only a modification of the well-known embryonic type of connective tissue; compare vol. iii., Fig. 1245. I have failed to distinguish any

intercellular substance, but think that the meshes are filled during life with fluid. The abundance of nuclei deserves special note. Around all the non-capillary blood-vessels the mesoderm is very different, for it exhibits distinct intercellular substance, with a tendency to fibrillar differentiation in quite a wide zone around the vessels; in this zone the cells become elongated and irregularly fusiform; around the larger vessels the inner part of the zone contains relatively more cells, which are more elongated and more regularly arranged; we may then say that a wide adventitia, and about the larger vessels a wide media also, is developed, without, however, either layer acquiring the full histological differentiation characteristic of the adult vessels. The epithelium of the villi undergoes a similar metamorphosis to that of the chorionic membrane proper, *except* that the cellular stage seems to be skipped usually, and the epithelial thickenings degenerate directly into canalized fibrine. Fig. 2893 represents a cross section of a seven months villus, which shows several thickenings, *a*, *a*, one of which, *f*, has degenerated into fibrine.

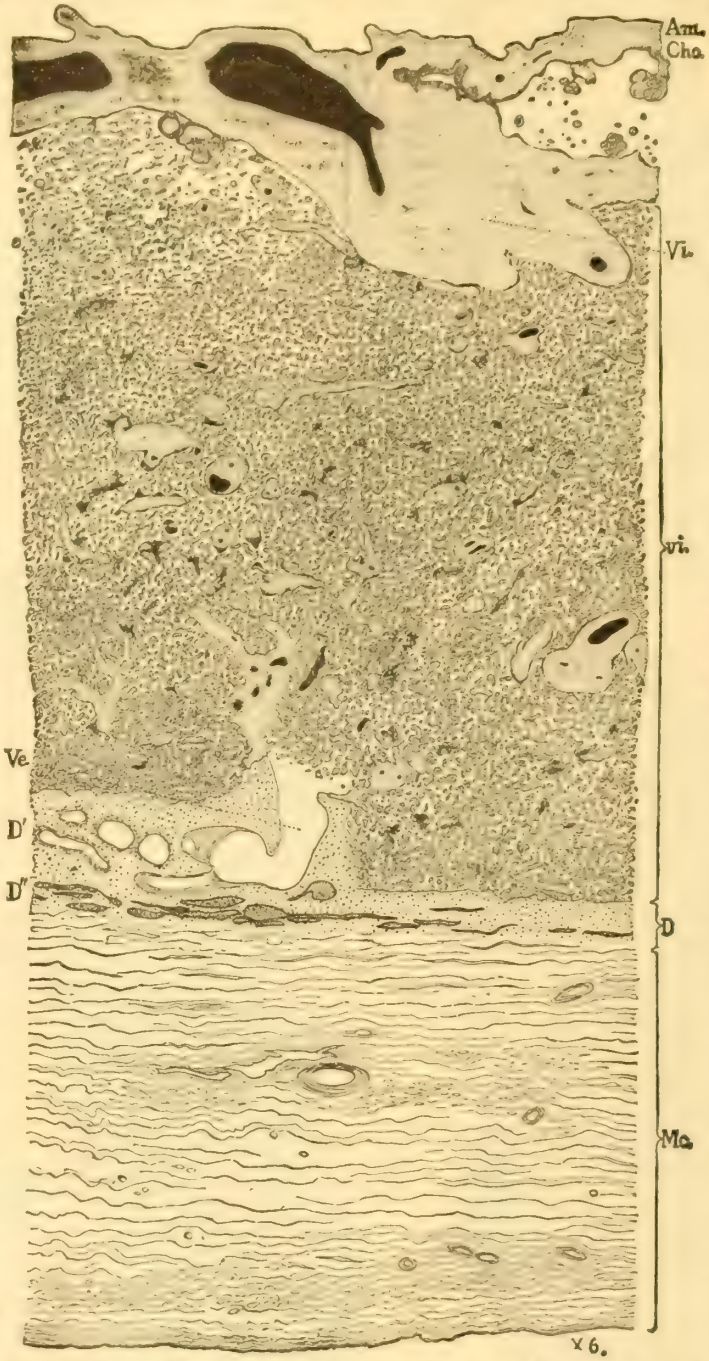

Fig. 2896.—Section Through a Normal Placenta of the Eighth Month *in situ*. *Am*, Amnion; *Cho*, chorion; *Vi*, villous trunk; *vi*, sections of villi in the substance of the placenta; *D*, decidua; *Mc*, muscularis uteri; *D'*, cavernous layer; *D''*, compact layer of decidua; *Ve*, uterine vein opening into the placenta. The fœtal blood vessels are drawn black; the maternal blood spaces are left white; the chorionic tissue is stippled, except the fibrine, which is shaded with lines; the remnants of the gland cavities in *D''* are stippled dark. (Drawn from nature by J. H. Emerton.)

Fœtal Circulation.—To follow the course of the fœtal blood-vessels within the placenta, the best method is by corrosion injections. These may be made either with fusible metal, wax, or celloidine. The first is specially suited for the study of the large trunks, the latter for that of the smaller vessels also. I have a very beautiful celloidine injection by Dr. S. J. Mixter, which, with others of wax and metal, has served as the basis of the following description: The veins leave the surface somewhat more abruptly than do the arteries, which give off more small branches to the surface than do the veins (see Fig. 2889). Both kinds of vessels leave the surface by curving downward for a short distance into the trunk of a villus, the vessels then divide, and their branches again take a more horizontal course, the branches then curl over downward, and after a second short descent toward the decidua, again send out horizontal branches. The result of this arrangement is a terrace-like appearance in the course of the vessels; they approach the uterine side of the placenta in this very characteristic manner. The number of terraces is variable; usually there are two or three, but sometimes there is only one, or they may number four, or even five. Arrived at the end of its terraces, the main vessel takes a more nearly perpendicular course, and rapidly subdivides. Immediately after entering the villi the arteries and veins give off but few capillaries, but after a short course in the main stalk of the villus the vessels give rise to many branchlets, and gradually the character of the circulation changes, until in the smallest villous twigs there are capillaries only (Fig. 2894). The vascular trunks have a marked tendency to dichotomous division (compare Fig. 2889), which is maintained within the villi to a certain extent; the arterioles and veinlets go off from their trunks at wide angles for the most part, and subdivide in the same manner, so that they spread out through the whole substance of the placenta. The vessels next the decidua take a more horizontal trend, like the top branches of a wind-swept tree. As the vessels run in the villi, of course the way in which the latter branch out determines the paths of the former; hence by following the distribution of the vessels we inform ourselves as to the ramifications of the villi. Thus the horizontal course of the vessels on the uterine side of the placenta corresponds to the well-known fact, that the ends of the villi attached to the uterus become bent, and adhere by their sides to the decidual surface.

The capillaries of the villi are remarkable for their large size, and on this account have been described as arteries or veins by E. H. Weber, Goodsir, and other

writers. Their calibre is often sufficient for from four to six blood-disks abreast. They are very variable in diameter, and are also peculiar in exhibiting sudden restrictions and dilatations (Fig. 2894). In the short bud-like branches there is often only a single capillary loop, but as the branch becomes larger the number of loops increases, and they form anastomoses. In branches large enough to serve as a stem, some one or two of the vessels may be enlarged, as may be seen in Fig. 2894; in the branches large enough to admit of it, there are two (or sometimes only one) longitudinal central vessels, an artery or vein, and a superficial network of capillaries (Fig. 2895). Goodsir and other early writers laid great stress on the formation of the capillary loops, but this feature is a common one in the development of the fœtal vascular system, as is also the width of the capillaries. In my opinion these peculiarities are characteristic rather of the fœtus than specifically of the placenta. In some of the older writers (Goodsir, Farre, *et al.*) it is asserted that the true capillary system disappears toward the end of gestation. I am unable to confirm this, but find instead that, in the slender terminal villi of the placenta at term there is often only a single, sometimes long, capillary loop; the capillary is very wide, and its width is probably the reason of its having been held formerly to be a vein or an artery.

Placenta in Situ and the Maternal Circulation.—The placenta in its natural position in the uterus follows the curvature of the uterine walls, hence its free or amniotic surface is slightly concave, its decidual surface is strongly convex. A vertical section is very instructive (Fig. 2896). The amnion is closely united with the chorionic membrane, which is quite thin; the uterine wall consists of the very thick muscular layer, *Mc*, and the thinner decidual layer, *D*. The muscular layer contains numerous slit-like cavities, the collapsed venous sinuses, and the well-known curling arteries, which, however, do not happen to appear in the actual section figured. The decidua varies in thickness, as is well shown in the figure, and exhibits in most parts the distinction between the upper compact layer, D', and the lower cavernous layer, D''. From a half to two-thirds of the whole area of such sections is occupied by innumerable sections of villi, *vi*, crowded together. The appearance of the villi varies according to the age of the placenta, for, as the organ grows older the small branches become more numerous; thus in Fig. 2896 there is a crowd of small sections of villi, but in a similar section of a younger placenta the fragments of villi would average considerably larger.

The problem of the maternal circulation has long been a vexed question. Waldeyer's recent investigations[46] seem to me to have settled the matter so far as the later months of development are concerned.* Waldeyer, with perfected methods, has confirmed in nearly every detail the account given by Farre, who seems to have been the only previous writer who understood the matter quite correctly. The arteries and veins open on the decidual surface, so that the maternal blood leaves the maternal channels and circulates in the intervillous spaces which are bounded by the chorionic epithelium. Waldeyer leaves it an open question whether this epithelium is not covered by a maternal membrane, but I cannot find any trace whatsoever of any covering over the villi except the fœtal epithelium. I must therefore say with Farre (*l. c.*, p. 722, foot-note): "I can arrive at no other conclusion than that the blood in the interior of the placenta is as much external to the maternal vascular system as it is while passing through a quill inserted between the divided ends of a vein in a living animal." The arteries and veins pass up from the muscularis and ascend through the decidua, to which they give off very few branches; hence the poverty of the decidua in blood-vessels (see vol. ii., p. 392). The decidual vessels have neither intima nor adventitia, but only endothelial walls. The walls of the *arteries* commence to thin out within the muscularis; the nearer they approach the decidua, the weaker do their walls become, until they are reduced to one layer of flat cells which border immediately against the decidual cells (*cf.* de Sinéty, "Arch. physiol. norm. path.," 1876). The change is not abrupt, nor does it take place evenly on all sides of the vessel. Can such a blood-channel still be called an artery? From its histological structure certainly not, but the fact that it is the direct prolongation of the artery, and that it is so much larger than any true capillary, leaves no doubt as to the correctness of the interpretation. At the last spiral turn the wall disappears on the upper side, and consequently the vessel opens directly into the intervillous chamber (Waldeyer). The relations of the *veins* differ somewhat. In the muscularis they appear already as great fissures with endothelial linings; they make no spiral turns, but approach the decidua at a gentle slope, their course being nearly parallel with the uterine surface. They gradually attain the surface, where they open widely (Fig. 2896, *Ve*). The ends of the villi may penetrate the cavity of the vein for a short distance. Sometimes a vein is so large as to occupy the whole diameter of the decidua, in which case its upper wall, *i.e.*, toward the villi, is wanting, its lateral wall rests against the decidua, and its lower wall against the muscularis. The decidual cells are less crowded around the veins than around the arteries (Waldeyer). The venous opening shown in Fig. 2896, *Ve*, tallies exactly with Waldeyer's descriptions, except that here the vein makes a sudden turn just before it opens.

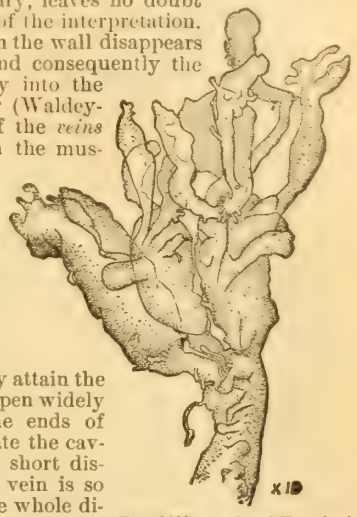

Fig. 2897.—Isolated Terminal Branch of a Villus from the Chorion of an Embryo of twelve weeks.

Form of the Villi.—Although the shape of the villi has been described in the article on the Chorion, a few words may be added for the sake of presenting some new observations and figures. Seiler[43] figured some villi of various ages, but they do not show the typical changes. At first the villi are short cylinders, slightly constricted at their bases (Reichert), but they soon begin to branch after the manner well indicated by Fig. 653 (vol. ii.). By the middle of the second month the villi appear more or less as in Fig. 2897. The branches are all constricted at the base, very irregular in shape, with rounded ends. The new branches begin as little knobs, which lengthen out first into short cylinders, then into slender clubs; as their growth continues their surface becomes irregular and itself, in turn, begins to develop branches, and gradually assumes an awkward cucumber form. All these phases are indicated in Fig. 2897. When the villi abort over the *chorion læve* (Fig. 2898), the formation of new branches ceases; the tissue begins to shrivel, and consequently the villi shrink and become ultimately filamentous. Over the placental area, *chorion frondosum*, on the contrary, the formation of new branches continues, but the terminal ramifications gradually alter in character, until in the placenta at term the end twigs are for the most part long and slender (Fig. 2890). The alteration progresses throughout the entire

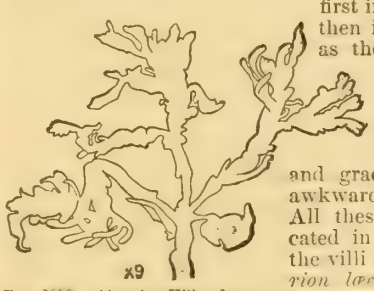

Fig. 2898.—Aborting Villus from a Chorion of the Second Month.

* What is the condition before the fourth or fifth month I am unable to say; there are reasons for thinking that up to that time the intervillous circulation of maternal blood is not established.

period of gestation, hence in the fifth or sixth month we find villi of the shape shown in Fig. 2899, intermediate between those of Fig. 2897 and Fig. 2898. The form of the villi is at all times excessively variable, yet the characteristics are so marked that it seems probable that the study of the villi could be used to determine approximately the age of a placenta, and hence be of forensic importance.

Fig. 2899.—Villous Stem from a Placenta of the Fifth Month.

Nutrition of the Fœtus.—The mechanism of the transfer of nourishment from the uterus to the child is not well understood. It is evident that the supply must come from the maternal blood and reach the fœtus through the veins of the umbilical cord; although the amniotic fluid may be a source of supply, as some have maintained, yet at most its rôle can be only secondary, and the main transfer of material must take place through the placenta. Our present knowledge of the structure of the organ renders it unnecessary to discuss the old theory, recently revived by Currie, of a direct communication between the maternal and fœtal vessels, for we know positively that no such communication exists. This theory has been put forward again, with the modification that the vascular walls will let small solid particles through. Thus Koubassoff, on the basis of some inconclusive experiments, sought to maintain that microbes and, ergo, other solid particles could pass from mother to embryo (see "Comptes Rendus Acad. Paris," t. ci., 508–510). More careful tests by Marie Miropolsky failed to confirm this (*Arch. de physiol. n. et. p.*, 1885, 101–108). A *second* theory, at present the best accredited, is that of diffusion, which finds its chief basis in the elaborate arrangements found in all placental types, for bringing the fœtal and maternal blood into immediate proximity. A *third* theory is that of Rauber,[35] who attributes the chief rôle in the nutrition of the embryo to the immigration, by way of the placenta, of maternal leucocytes. A *fourth* theory attributes an active part to the utricular glands, which are supposed to pour out a nutrient secretion into the intervillous spaces, where it is taken up by the chorionic villi. It is impossible at present to form a final judgment upon these theories; it seems to me probable that during the first half of gestation in man the intervillous spaces of the placenta do not normally contain maternal blood, and it seems possible that it is the function of the uterine glands to nourish the embryo during that period. Later, when the maternal blood bathes the villi, it is likely that the transfer of material is effected chiefly by simple transfusion. Rauber's theory has not commended itself to me.

Types of Placenta.—It is probable that in the earliest type of placenta the allantois was still a rudimentary structure; the so-called allantoic vessels ran on past it and ramified upon the chorion, which threw out villi to absorb by an increased surface. The villi covered the whole chorion. They developed further, as the increase in the absorbent capacities was advantageous. From this simple type all the existing modifications in placental mammals appear to me to be derived. The first marked divergence was in the manner of connection between the fœtal villi and the uterine walls. On the one line of differentiation, we find the surface of the chorionic villus highly vascular and closely fitted against the uterine wall, which is also highly vascular (Fig. 2900), or they may partly separate from the uterine wall, as happens in the areas of Eschricht in the pig's chorion, in man the separation is carried to an extreme, only the tips of a few of the villi being attached to the uterus; there is thus a wide space or cavity between the membrane of the chorion at the uterine surface, in which the racemose villi hang. By the abortion of the villi over most of the chorion the human placenta becomes of the true *discoidal* type. It is always a *true chorionic placenta*, neither the allantois or the yolk sack (umbilical vesicle) taking any part in its formation. In many mammals, however, one or both of these appendages lays itself against the chorion and shares in the placenta. Other modifications are produced in various classes by the variations in the disappearance of the villi; at least, with our present knowledge, this appears the best morphological interpretation of the zonary and cotyledonary forms of placenta. All types of placentæ are to be reduced *primarily* to variations in the chorion, and particularly in the form and distribution of its villi, and to the modifications in the uterine mucosa, and *secondarily* to the relations established between the allantois and yolk. It should never be forgotten that the placenta is essentially a chorionic organ. The placenta varies extremely in the different classes of mammalia, and is therefore very interesting to the comparative embryologist; but on the other hand, the human placenta differs so much from

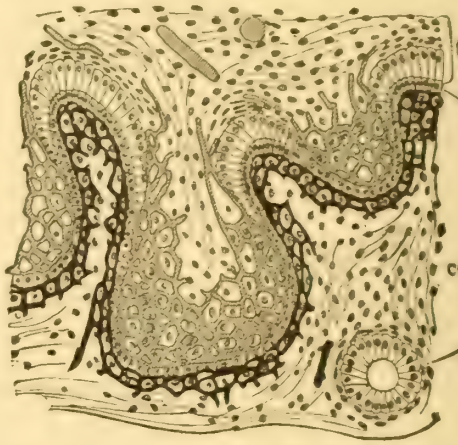

Fig. 2900.—Chorion *in situ* of a Pig. *Cho.* Chorion; *ep*, uterine epithelium; *conn.* connective tissue of uterine mucosa; *gl*, utricular gland. The fœtal blood-vessels are shaded gray, the maternal vessels black. (After Tafani.)

that of other types, that the physician cannot replace the study of it by the study of that of any other animal, except perhaps the anthropoid apes.

Literature.—The literature of the placenta is very extensive. Part of it has been cited with the articles Chorion and Decidua. The best article known to me is that of Arthur Farre[34a]; it is a great deal better and more accurate than most subsequent writing on this subject. The next most important writings in English are those of Turner, and of Balfour in his "Comparative Embryology." In the following list, a few only of the papers are mentioned. Ercolani's numerous papers are summarized in Romiti's, "Embriogenia umana." Of recent papers, I will mention especially, Tafani[44] and Waldeyer.[46]

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Charles Sedgwick Minot.

PLAGUE, THE (Pestis, Pestilentia, Pestilential Fever). During the Middle Ages many severe epidemic diseases were included under the term plague. This confusion of terms arose largely from the following definition of Galen: "When a disease attacks a number of persons in one place it is an epidemic, and when many are destroyed it is a plague." In more recent times the term has become limited to a pathological process of definite character, and one presenting definite symptoms during life. This form has sometimes been called the bubo plague.

Definition.—Plague is a severe contagious fever, which has occurred in epidemics at different times and in different places. It is characterized by extreme debility, and by the presence of buboes and carbuncles. It is of short duration and exceedingly fatal.

History.—There are few authentic accounts of the disease before the sixth century. The history given by Rufus of Ephesus, a physician of the time of Trajan, is probably reliable, as his description of the disease is very accurate, and harmonizes with that given by the more recent writers. In A.D. 542 the true plague was present in its most severe form in Constantinople. Between that time and the sixteenth century numerous outbreaks have been recorded.

In many cases the accounts have been obscured, owing to a confused idea as to the real nature of the affection, and to the placing of a number of diseases under the same head. After the sixteenth century the accounts were of a more reliable character, and the epidemics described under the head of plague were, in all probability, cases of that disease. The black death, whose ravages have been so graphically described by Haecker, was no doubt, in many instances, the true plague. From the following brief enumeration of epidemics it will be seen how great were the ravages of the plague.

In the sixteenth century there was one outbreak, that in Egypt. In the seventeenth century there were two invasions in Egypt, nineteen in Germany, eleven in Italy, six in England, eleven in France, four in Russia, four in Turkey, three in Spain, two in Holland, two in Belgium, and one in Switzerland. In the eighteenth century epidemics of the plague occurred nineteen times in Egypt, seven times in Turkey, four in Dalmatia, four in Germany, three in Russia, three in Spain, twice in Poland, twice in Greece, once in Italy, once in Sweden, once in France—that of Marseilles, 1720–21. During the present century there have been eight outbreaks in Egypt, six in Turkey in Europe, three in Greece, two in Syria, two in Italy, three in Russia, two in Turkey in Asia, one in Germany, one in Dalmatia, one in Morocco, and one in Persia.

The epidemics most noted for their severity were: (1) That of Constantinople, in A.D. 542, which is frequently called the Justinian plague; (2) the outbreak in England, in 1665; and (3) the epidemic in France, which commenced in Marseilles in 1720.

The plague thus existed in Europe for over a thousand years, until 1844, when it disappeared from both Europe and Asia. It was then thought that the disease was one of those scourges of the Middle Ages which could not exist under a higher civilization. These expectations were not realized, as it again showed itself in Arabia, in 1853; in North Africa, in 1858–59; and in Persia and Hindostan, in 1871. Between the years 1873 and 1877 almost every part of Arabia was ravaged by the pestilence. The last outbreak of the disease occurred in the province of Astrakhan, on the banks of the Volga, in December, 1878. It was at first of a mild nature, but soon became so fatal that very few recovered of those who were attacked. The infected district was made up of seven villages, with the intervening country districts. The whole population numbered about ten thousand souls. The disease first showed itself in October, 1878, when the cases were mostly of a mild nature; and it was not until December that the disease assumed its usual violence, and that congestion of the lungs and spitting of blood became prominent symptoms. The disease generally proved fatal in from one to three days. The three doctors and the priest died of the malady. It existed in this severe form until January 1, 1879, when it began to decline, and by the end of the month it had entirely disappeared.

ETIOLOGY.—*Predisposing Causes.*—Although we may consider plague as a germ disease, and one which cannot arise spontaneously, yet the malady can only exist when the surroundings are favorable. The predisposing causes may be divided under the following heads: 1, Surroundings; 2, climate; 3, season; 4, individual predisposition.

The most potent predisposing cause exists in the nature of the surroundings. Badly-ventilated rooms, crowded dwellings, the accumulation of decomposing animal and vegetable material, are the conditions most frequently found where the plague exists. It was at one time supposed that unburied corpses were the principal cause of the infection, and that the disease could arise spontaneously in this way. In addition to the unhealthy surroundings, the inhabitants of the infected districts have been of low physical vitality, partly from the conditions above mentioned, and partly from insufficient and unwholesome food. We are not now in a position to realize the utterly wretched state of the inhabitants in some of these Eastern countries. The history of Eygpt in this particular is of interest, and throws some light on the causation of the plague. In ancient times Egypt was known as a particularly healthy country, and was so described by the older historians. During the fourth century the custom of embalming the bodies of the dead was discontinued, and the advent of Mahometanism, two centuries afterward, reduced the inhabitants to the lowest state of civilization. The dwelling-houses, small, ill-ventilated, and crowded, were surrounded by putrefying masses of animal and vegetable matter, including the human dejecta, from which arose a stench which was frequently overpowering. The cottages had simply an earthen floor, and a few feet underneath were buried the dead bodies of the previous occupants. These also emitted a horrible odor. The inhabitants lived on the most unwholesome food—rotten cheese, decayed vegetables, and semi-putrid fish were common articles of diet, and this often in very insufficient quantities. When such was the condition of the villages one can form some idea of the sanitary state of Cairo, a city of two hundred thousand inhabitants, where the same kind of dwellings, with the same surroundings, were crowded together.

It has always been found that it was only under such conditions that the plague existed in its most violent form. The disappearance of the plague from Egypt and Turkey in 1844 was contemporaneous with the introduction of better sanitary regulations, and its return in 1854 was due to an abandonment of such strict sanitary rules.

Marshy districts, such as are found at the mouths of rivers, are favorable to the spread of the disease.

It has been frequently observed that a sickly season preceded the appearance of an epidemic, and a heavy atmosphere has always been noticed. During this time wounds would not heal rapidly—a scratch would become a running sore, and a slight pressure would produce a boil or carbuncle.

Climate and seasons play but a secondary part in the spread of the disease. It is favored by moderate warmth and dampness. Very hot, dry weather, as well as very cold weather, will check the progress of the disease, but will not entirely suppress it.

Individual predisposition presents the same peculiarities as in other epidemic diseases. Some will not contract it although exposed in every way. Others, again, are attacked after very slight exposure. Sex has no effect upon predisposition. The disease is seldom contracted by persons over fifty years of age. One attack does not protect the individual from a second one.

Exciting Causes.—Plague is a contagious disease in the ordinary acceptation of that term. This has been demonstrated in various ways.

1. There are many instances of its having been introduced into cities previously healthy by individuals from infected districts. It was so introduced into Moscow after one hundred and thirty years' freedom from the disease. In 1720 it was brought to Marseilles in a ship from Alexandria, and spread, producing a frightful epidemic. It was also carried to Malta in 1815, an island which had been one hundred and thirty-seven years free from it.

2. The disease is often confined to the district originally attacked, when all cases are isolated and a rigid quarantine established. As an instance of such rigid quarantine, the town of Noja, in Italy, might be cited. The plague appeared there in 1815. Two trenches were dug around the city and two cordons of soldiers were established, so that no person could either pass in or out. The result was that the disease did not spread into the surrounding districts. Although this system protected the outsiders, it was not the best for the inhabitants of the town itself.

3. A few instances of inoculation have been related. Griesinger gives the case of Surgeon Whyte, in the Egyptian plague of 1804. Other instances have been reported, but none of them is reliable.

4. From all the evidence which has been collected it is probable that the plague can be carried by clothing, bedding, etc., which have come into intimate contact with persons suffering from the disease. No form of merchandise is likely to convey the poison.

5. It is still a disputed point as to whether the disease can be directly communicated from one person to another. The medical men who studied the malady as it existed in Egypt came to a negative conclusion upon this point. It is indisputable, however, that the plague has been transmitted from infected districts to places at a great distance. It was, for example, carried from Alexandria to Marseilles in 1720. It would appear that, in order to propagate the disease, infected foci must be first formed, and from these foci the disease spreads to healthy districts. In order that such a centre may be formed it seems necessary that a number of persons should have the disease, and that they should live under certain conditions and surroundings, such, for example, as have already been described.

Infected foci are often conveyed long distances by means of vessels. Instances have been known of the infection remaining some time after the removal of the patients.

The virus of the plague when introduced into the system, probably by inhalation, seems to attack first the lymphatic system, producing inflammation of the glands and ducts.

The length of the time of incubation generally varies from two to five days. It may, however, be as long as seven or eight days. Epidemics may last for weeks, months, or years.

It would appear that after a time the virus becomes weaker, as the cases which occur in the latter part of an epidemic are always much milder in character. Sporadic cases have occurred in Egypt from time to time. Some have thought that such cases were, perhaps, of syphilitic origin. It is probable, however, that the sporadic cases bear the same relationship to the plague that sporadic dysentery does to the epidemic form. Severe epidemics have frequently occurred with mild ones between.

The plague has not yet been investigated by the method which is now adopted in the study of contagious diseases. We cannot, then, speak definitely of the bacteria of plague. When, however, we consider the nature of the disease, and the manner in which it spreads, we can have little doubt that plague is really of bacterial origin, and that this will be demonstrated if an opportunity arise. It is probable that the germs can grow only in a suitable soil, resulting from such miserable and wretched hygienic surroundings as have been described, and which, fortunately, are but seldom found in the habitable globe at the present time. In order that the germs may exist in the atmosphere, and may enter and grow in other individuals, it appears to be necessary that there should be a concentration of the poison. It may be that the bacteria undergo two or three stages of development, and that this further development can be attained only under the most favoring circumstances. It would appear, also, that the germs in time use up, so to speak, the soil upon which they first grew, and thus the disease gradually disappears.

Can the plague arise spontaneously? This is a ques-

tion which at various times has given rise to much discussion. With our present knowledge of such diseases, we must conclude that such origin is impossible. It is probable that the germs exist at all times in those Eastern countries where the plague is endemic, and that when a favoring combination of circumstances takes place the disease may become developed and spread. At first single individuals may be attacked, and after a time, when the proper soil is present, the disease may become established in all its violence.

Clinical History.—The first cases of the disease in an epidemic are difficult to recognize, but in time the symptoms become more marked. The course of the malady may be conveniently divided into four stages: 1, The stage of invasion; 2, that of intense fever; 3, that of localized inflammatory lesions; 4, that of convalescence.

The stage of invasion lasts two or three days. The symptoms are loss of appetite, a feeling of fulness and heaviness in the head, paleness of the countenance, together with dulness of the intellect. Patients have a staggering gait and appear as if intoxicated. Nausea, vomiting, and diarrhœa sometimes occur in this stage.

The stage of intense fever commences by vomiting and chills, followed by high fever. The debility is extreme. The skin is hot and dry. The conjunctivæ are congested and the pupils dilated. Pulse rapid and weak. The patient passes rapidly into the condition of typhus. He becomes restless. The conjunctivæ become still more congested, and the pupils are dilated. There is loss of hearing; the lips become swollen and the tongue covered with a thick white fur, which afterward becomes dry, cracked, and dark-colored. The patient will not answer questions. The muttering delirium and stupor often deepen into coma. There is often pain and swelling in the hypochondrium. The urine is bloody and scanty. Catarrh of the bronchi and, sometimes, pneumonia are present.

Shortly after the commencement of the second stage inflammation of the lymphatic glands takes place, but the swelling is not very great until the third stage is established. The glands first affected are those of the groin, and then those in the axilla. The glands in the neck and beneath the lower jaw are also attacked, especially in severe cases. The swelling may be slight or very great. In the groins and axilla several glands become adherent on account of intervening inflammatory exudation, thus forming masses sometimes two or three pounds in weight. In some cases there is a swelling of all the lympathic glands of the body. Following the swelling of the glands is the appearance of carbuncles on the arms and legs. In favorable cases there is at this stage a heavy sweating, followed by disappearance of the fever. The buboes suppurate and the carbuncles become limited in area and slough, leaving a healing surface. In fatal cases death may take place at any time during the attack, (1) from collapse during the first forty-eight hours; (2) from coma and convulsion in the second stage; (3) from the typhoid condition and pyæmia in the third stage. In the most severe form death has been known to take place inside of twelve hours. Cases have been recorded of persons falling on the street and dying in a few hours. In such cases there is a virulence and concentration of the poison sufficient to produce collapse. In the majority of fatal cases death occurs on the third or fourth day, or during the second stage.

Sometimes the disease is very mild. The patient may not go to bed. The swelling of the lymphatics is slight and they do not suppurate. Such cases occur in light epidemics or in the latter part of a severe one, when the virus seems to have spent itself. In some cases there is jaundice, nose-bleed, vomiting of blood, and suppression of urine.

Pathological Anatomy.—During the plague of Egypt, in 1834 and 1835, a large number of post-mortems were made by the French physicians sent out to investigate the disease. The following conditions are found: The body is usually well nourished. The skin presents petechiæ, carbuncles, and sometimes openings into suppurating glands. Roseola, herpes labialis, and miliaria are found during life. The carbuncles often present large sloughs surrounded by inflamed tissues. No change is found in the brain-substance or in the dura mater. Ecchymoses are often present in the pia mater. The results of bronchitis, pneumonia, and sometimes gangrene are found in the lungs. Small extravasations exist beneath the pleura. The heart is flabby, and the right side is dilated by fluid blood. The liver is slightly swollen. The spleen is enlarged, often to two or three times its normal size. The mesenteric glands are swollen and sometimes black. Extravasations of blood are present in the kidneys.

The principal changes are found in the lymphatic system. The glands are swollen, and the inflammation extends more or less into the surrounding tissues. In this way large masses are formed, which break down and suppurate. These masses often exist in the axilla, and the inflammation extends sometimes to the pleura.

The lymphatic ducts also show evidences of inflammation.

Diagnosis.—In the earlier stage of an epidemic it is often difficult to make a diagnosis, as the disease in such cases does not run a typical course. While the plague is at its height the diagnosis is usually clear. Although the lesions differ very much in different cases, yet there is a similarity in the whole course of the disease.

It may be confounded with typhus, malignant pustule, and pernicious intermittent fever. The principal diagnostic points are the great hebetude and collapse, the presence of high fever and the appearance of buboes and carbuncles.

Prognosis.—Plague is an exceedingly fatal malady. Milder cases occur at the commencement and toward the end of an epidemic. There are also milder epidemics, in which the prognosis is better.

At the height of the invasion, when the poison exists in a condensed form, many patients die within twenty-four hours after they are attacked. In such cases death ensues from collapse. Suppuration of the buboes is a good sign, in that it demonstrates that the patient has passed through the most dangerous stage of the disease. Death often comes later from pyæmia or septicæmia.

The presence of carbuncles, when they show limitation, is not a bad sign.

In the course of the disease, heavy sweating, remission of fever, return of the natural appearance of the countenance, and cessation of the nervous symptoms, may be considered as favorable signs. When buboes occur in the neck and petechiæ on the skin, and muttering delirium, suppression of urine, and severe diarrhœa are present, the prognosis is grave.

Treatment.—There is no specific for plague. Like other severe fevers of a low type, it is best treated by supporting measures. The patient should be moved into a pure atmosphere.

Cleanliness and good ventilation should be enjoined. Good food of such a character as can be easily assimilated should be given, together with stimulants. Alcoholic stimulants have been of great service. Quinine has been given in large doses with some success.

All forms of lowering treatment, such as mercurials, blistering, purgatives, etc., have been found injurious.

Prophylactic Treatment.—In this disease preventive measures are of the greatest importance. Among the most effective may be mentioned: 1. The removal of the individual to a healthy, dry situation, surrounded by plenty of fresh air. This gives the best chance of recovery, if the person does not escape an attack, and prevents that condensation of the poison which has always been found so fatal. 2. The establishment of a most rigid system of quarantine, so that individuals cannot go from infected to healthy districts until it is quite certain that they will not take the disease. 3. All articles of clothing which were brought in contact with diseased persons should be thoroughly disinfected or burned. 4. The dwellings should be purified and disinfected. The inhabitants should have plenty of food, and their general hygienic condition should be improved.

The limiting and suppression of the plague in Astrakhan were largely due to the enforcement of rigid quarantine laws, together with sanitary regulations. Three military cordons were established, one around each village, so that no one could pass either in or out until forty days after the last case of disease. A second cordon was established around the entire group of infected villages, and a third around the whole province. *James E. Graham.*

PLANTAIN, Codex Med. The flowering plant of *Plantago major* Linn., *P. media* Linn., and *P. lanceolata* Linn., three common European weeds, of which the first and last have made themselves pretty well at home in our fields and door-yards. They are very slightly acrid and bitter, somewhat astringent, and quite mucilaginous; containing a little of some sort of *tannin*, some *resin*, some "*bitter extractive*," and considerable *mucus*, but no more active substances. They are almost obsolete as medicines, but have formerly been esteemed as astringents, hæmostatics, and even antispasmodics, and were used locally in leucorrhœa, hæmorrhoids, conjunctivitis, and scrofulous eruptions.

The order *Plantaginaceæ* is a large one, of several hundred species, but none having active properties. The seeds of one, *P. Psyllium* Linn., have an abundant mucilage like flaxseed and are employed in the arts for sizing cloths, etc., and occasionally in medicine as collyria or demulcent washes. *W. P. Bolles.*

PLASTIC SURGERY. Plastic surgery is that department of the operative art which contemplates the repair of defects and deformities, congenital or acquired. Limited in its early history to the restoration of parts destroyed by trauma, plastic surgery has, in the course of centuries, widened its range of utility until its present achievements have been carried to all parts of the body covered by the general integument and to many of the cavities lined with mucous membrane. When the nose is destroyed by lupus, the eyelid shrivelled out of all semblance by chronic inflammation, the palate cleft, the fingers webbed, or the arm bound down by the scars of a burn; when a gastric or vesico-vaginal fistula, an eversion of the bladder, or ruptured perineum makes life a burden—a plastic operation is the only measure of relief.

History.—The history of plastic operations presents fluctuations of use and oblivion unknown to the generality of operative measures. For its earliest development we must look to the shores of the Ganges, where from time immemorial mutilations of the face were inflicted in the way of punishment or revenge.

Later the practice became the portion of the potters and brickmakers, who knew nothing of sutures, but retained the parts in position by the application of clay. There is no evidence that the skill of any of the operators of antiquity went beyond the restoration of mutilated noses, or that they attempted the repair of other parts. It is generally believed that before the Christian era the Brahmins had achieved great proficiency in the restoration of noses, forming them from integument brought down from the forehead or transplanted from another individual, and preferably from the gluteal region. What is truth and what is fiction of the rhinoplastic skill of the early priests of India only appears from the recent translations of relevant parts of the *Susrutas Ayurveda*, according to which the nose was formed from the integument covering the cheeks. "The physician takes a leaf the size of the nose to be formed, and, placing it on the cheek for a measure, raises a flap of skin in such a manner as to leave it attached at one part. After vivifying the scarred part the new nose is quickly brought in position, elevated, and retained by placing two tubes in the nostrils."[1] The classical writers of Greece and Rome were for the most part unacquainted with transplantation of skin as a method of relieving defects, which were treated only by freshening the edges by incisions and drawing contiguous portions of skin together.

On the other hand, Celsus certainly entertained a rational idea of the gliding of flaps. He advised that the defect be removed in the form of a square and that two parallel incisions be continued transversely outward and inward, so that the loosened edges might be easily united. If this could not be done, he recommended that two semilunar lateral incisions, which should involve only the skin, be made with the concavity looking toward the defect.[2]

Although Galen and Paul of Ægina repeated the precepts of Celsus, the little that was known of plastic operations lapsed into an oblivion even greater than that which befell general surgery, and from which it was not recovered for over a thousand years. In 1442 Pietro Lonzano, Bishop of Lu, published a statement in the "Annales du Monde" that a Sicilian named Branca had found a new method of supplying the loss of a nose. Whence he derived his knowledge does not appear. Among the pupils of Branca was his son Antonio, who had improved and extended his father's method by taking the integument from the arm, and by replacing the loss of lips and of ears in the same way. Plastic surgery doubtless spread rapidly in Italy from the time of the elder Branca, since Vesalius, Fallopius, and others make mention of it. It remained, however, for Gaspardus Taliacotius or Tagliacozzi, Professor of Anatomy at Bologna, to develop plastic surgery to a degree unknown before him, and to publish the first scientific work on it two years before his death in 1599. In it are described his methods of operating and of retaining the parts in position; and the illustrations accompanying the text have been utilized from century to century by almost all authorities who have written upon the subject. A father of conservative surgery in its best sense, respected by his confrères and beloved by his students, Tagliacozzi well merited the marble statue erected after his death in the amphitheatre of Bologna. In this monument he contemplates a nose which he holds in his hand. The methods of Tagliacozzi failed to obtain a permanent foothold—Paré, Fabricius, Heister, and many others denied the possibility of success. A little over a hundred years after Tagliacozzi's death, the art he had perfected had again fallen into disuse. Dionys, Desault, Richter, and Chopart only mentioned his practices to condemn them. Such was the state of plastic surgery when, in 1794, a Madras journal brought to England the account of a successful rhinoplasty practised by one of the Koomas, who transplanted skin from the forehead. Although the first rhinoplasty in England was made by Lucas, it was not a success. In 1814 Carpue was more successful in replacing the lower portion of the nose. In 1816 Von Graefe introduced plastic operations on the Continent, giving preference to the method of Tagliacozzi. Since the last-mentioned date the utility and feasibility of plastic surgery have not been seriously questioned, and particularly within the last twenty-five years so many additions and improvements have been made that the achievements of the present day doubtless eclipse the best efforts of all former masters in this special art. Associated with the more recent progress of plastic operations are the names of Skey, Liston, and Fergusson in England; Sedillot and Jobert in France; Dieffenbach, B. v. Langenbeck, Fritze, and Thiersch in Germany; and the elder Pancoast and Gurdon Buck in this country.

Indications.—Congenital or acquired defects and deformities demand the resources of plastic surgery when, from their exposed position, æsthetic reasons make their removal desirable, or when disturbances of function and impaired utility are plainly due to them in parts that are hidden from view. Hence it is evident that, regarding the imperativeness of plastic operations, cases in which they are indicated may properly be divided into two groups, in which the necessity to interfere varies as much as the end to be obtained. In the first class of cases the operation is designed merely to improve the appearance of the patient by removing a distorting scar, by suturing the fissured lobule of an ear, or by elevating a depressed nose. Here the indications for an operation are far from imperative, and it is not infrequently the importunity of the patient that impels the surgeon to operate. It is well to remember that operations done solely for cosmetic effects are ordinarily the least satisfactory; it is within

the experience of almost every surgeon that results obtained by plastic operations in this group of cases, although eminently gratifying to himself and deemed excellent by his colleagues, are sources of deep disappointment to the patients themselves. In the second group of cases the chief indication for operative measures is the repair of defective function or the protection of parts that are exposed. When the absence of the lower lip, destroyed by lupus or noma, permits of the continuous loss of saliva, derangements of the digestion and of the general health necessarily follow. When the lower eyelid is everted or lost, the defect causes characteristic changes in the eye and face which often make vision imperfect, and the overflow of tears adds the suffering from an eczema to the other ills of the patient. A large urethral fistula at the peno-scrotal angle, while neither disfiguring nor detrimental to health, is a bar to the full exercise of the procreative function. In each of these cases the indication for recourse to plastic surgery is apparent, and its imperativeness is commensurate with the impairment of function caused by the deformity. To this group of cases belong extensive destruction of the lips, the nose, or eyelids; cleft palate, cicatrix from burns, or webbing of the fingers; fistulæ—urethral, vesico-vaginal, or recto-vaginal; lacerated perineum, and extrophy of the bladder. In this group of cases must also be included those in which the operative production of a defect is to be immediately followed by its closure by plastic means. Thus an ulcer of the leg that has proven refractory to all other means frequently yields to excision and immediate transplantation of skin; or an extensive epithelioma of the lip can be relieved only by extensive ablation of the part, the large defect being at once closed by dermatoplasty.

In considering the urgency of a plastic operation, it is necessary to consider the pathological nature of the defect which it is intended to overcome. A loss of substance may be congenital, traumatic, or the result of destructive neoplasms, like lupus, ulcerative syphilides, or epithelioma. In congenital deformities plastic operations are generally not urgently demanded, unless, as in the case of deficiency of the rectum, the life of the child depends upon their correction. But there are milder cases, congenital in character, in which greater deformity can be avoided by early interference. This is true in cases of harelip associated with cleft palate. In simple fissure of the lip the surgeon may abide his time. In complicated cases, on the other hand, early closure of the labial cleft must be advocated, since it has an undoubted influence in approximating the edges of the bony cleft and greatly increases the probability of success in subsequent attempts to close it. In two complicated cases in which I have thus operated during the first week the result was eminently satisfactory. Due regard should necessarily be paid to the general nutrition of the child before a plastic operation of considerable severity and entailing the loss of no slight amount of blood is performed. Defects that are traumatic in origin almost invariably demand removal by plastic operation while the wound is in condition to promise immediate union. This applies particularly to wounds of the face, the soft parts of which are so mobile that they may be stretched to almost any extent, provided the soft structures be thoroughly lifted from the bone. When suppurative processes have been established it is, as a rule, best to delay operative procedures until complete cicatrization shall have taken place. When the loss of substance is inflicted by the surgeon in the removal of malignant growths, its immediate repair is indicated, since there is every reason for believing that when this is accomplished the danger of recurrence of the primary disease is materially decreased. In such cases the all-important object of the operation is the removal of all diseased tissue, irrespective of the size and form of the wound that remains. In the category of defects that result from destructive inflammations, or from tubercular or syphilitic ulcerations, operative measures are never indicated until the complete cessation of the original disease. It is in these cases that patients are most importunate in their demands for relief, and injudicious haste on the part of the surgeon is most frequently followed by disaster. Until a lupous or syphilitic ulceration is entirely under control, until, indeed, the whiteness of the cicatrix and the absence of other evidences of constitutional vice give us reasonable assurance that there is no tendency to recurrence, a plastic operation should not be attempted. An operation too soon performed will often give a new impetus to a disease that has simply been dormant.

Nomenclature.—A number of terms have been suggested to designate plastic operations. French and German writers generally prefer the word autoplasty (*αὐτός*, self, and *πλάσσειν*, to form). In rare cases, in which the transplanted tissue is taken from a subject other than the patient, this term is evidently inappropriate. To overcome this objection, Velpeau and Guérin have suggested the word anaplasty, signifying to form anew or again. In this country and in England these terms have been generally discarded for the less objectionable one of plastic surgery. When, however, such an operation is performed for the repair or new formation of a particular part, the latter properly gives to the operation a particular name. Thus the formation of a nose is called rhinoplasty; of the lip, cheiloplasty; of the eyelid, blepharoplasty; of the mouth, stomatoplasty; of the urethra, urethroplasty, etc. The scope of this article will not permit the consideration of all the plastic operations. Those of the palate, fingers, urethra, perineum, and vagina are treated of in other volumes of the Handbook, while in the following pages will be studied the principles underlying plastic operations in general, and the methods of repairing deformities and defects of the face only.

The underlying basis of plastic surgery is the inherent vitality of the various tissues of the body. This permits them, after partial or total separation, to maintain an independent existence for a greater or less period, and to form new and permanent attachments when brought into contact with freshly wounded surfaces in proximity to, or at a distance from, their original sites. The introduction into defects of particles of epidermis, of the cutis vera, of tendon, or of bone, which have been entirely severed from their former connections, constitutes transplantation or grafting. In plastic operations proper, this severance is never complete, a small bridge always being left through which the part to be utilized in the closure of a defect continues to live under the influence of the circulatory, and probably, also, of the nervous, apparatus of the structures whence it was taken, until perfect agglutination in its new position ensues. This occurs in from twenty-four to forty-eight hours, when no untoward complications in the process of wound-repair supervene. By the end of a week the union is solidified by the free interchange of blood-vessels between the edges of the defect and the part inserted into it. In wounds of skin more than in those of any other structure is there a manifest tendency to early and firm repair, without which plastic operations would rarely succeed.

Methods.—The pathology, nature, and extent of a cutaneous defect, and the condition of contiguous parts, will direct the surgeon in the choice of one of a number of methods that are at his disposal. Thus he may utilize the integument from a near or distant part of the body for its closure. Referring, for the present, to the former method only, the skin in the vicinity may be made serviceable by (1) traction, (2) by gliding, and (3) by transplantation of skin-flaps. While typical illustrations of each of these methods differ sufficiently from each other to warrant a separate consideration of each, it is well to bear in mind that in their practical application the simpler often verges into the more complicated procedure.

1. The method of closing a cutaneous defect by traction on the vivified edges of the integument surrounding it is based on the extent to which skin can be stretched and yet retain its vitality. This is well illustrated after removal of the breast, in which even the largest wounds can ordinarily be readily closed. In the surgery of the face, however, plastic procedures by traction alone are justified only in wedge-shaped or oval defects, the mar-

gins of which can be easily approximated and retained in position without dangerous traction on the sutures.

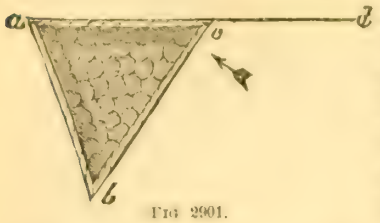


Fig. 2901.

If there be any strain on them after complete closure of the wound, it may be relieved by an incision through the skin on either side of the wound, parallel with, and at a short distance from it. This method is therefore applicable for the closure of fissures and fistulæ, and for the removal of prominent and ungainly cicatrices.

2. When the size and form of a defect preclude the possibility of its closure by traction alone, the skin in the immediate vicinity may be dissected up in a patch of requisite size, and by a process of gliding be brought edgewise into the position of the part to be repaired, where, after proper adjustment, it is retained by sutures. Triangular and rectangular defects, such as result from

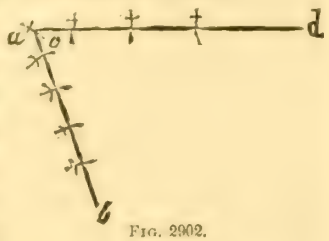


Fig. 2902.

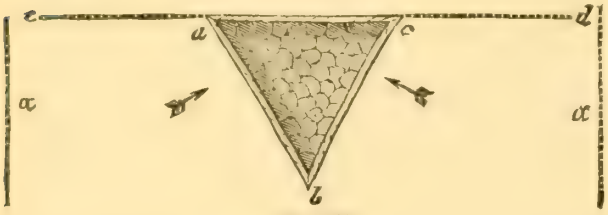


Fig. 2903.

the partial removal of the lower and upper lip, respectively, can be best remedied in this way. This method

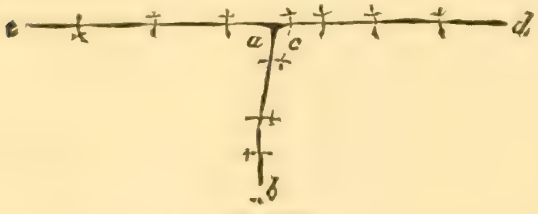


Fig. 2904.

of operating by gliding, although mentioned by Celsus, as Linbart suggests, was probably practised before his time, since every operator, even if without previous knowledge, would naturally adopt it.

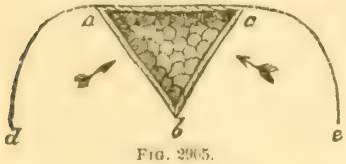


Fig. 2905.

3. The above methods are applicable only when the integument in the *immediate* vicinity of the defect can be utilized. If this is not feasible the borrowed integument, after being given the shape of the defect and being raised from its substructure, is transferred into the defect, but retained in relation with the tissues of its former position by means of a pedicle. Around

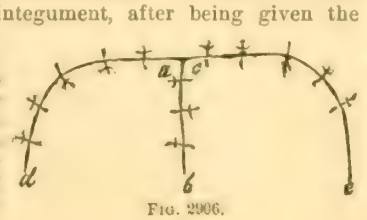


Fig. 2906.

this latter the flap must then necessarily be turned or twisted. Such a flap, in being transferred to its new site,

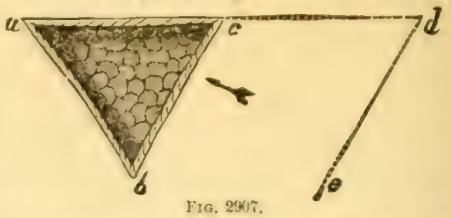


Fig. 2907.

may be made to describe an arc of 90°, or even 180°. In order that the raw under-surface of the flap may be

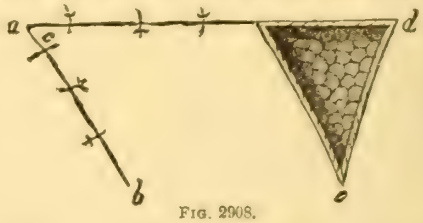


Fig. 2908.

everywhere in contact with the subjacent surface, the skin bounding this must in part be displaced. "This displacement, however, should be effected in such a way that the displaced skin, retaining a connecting pedicle for its support, may be made to change places with the transplanted flap, and thus contribute, as far as it can, a covering for the surface that has been left bare.[3] As illustrations of this method may be cited the formation of a nose from the forehead, and of the upper eyelid from the integument of the temple.

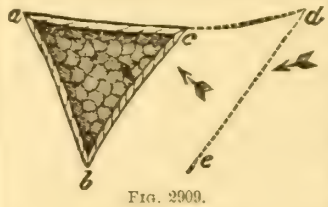


Fig. 2909.

Fig. 2910.

Although every case requiring a plastic operation is a law unto itself, there are certain characteristic forms of defect the effacement of which can be effected in well-defined ways. In following the diagrammatic representations of Denucé,[4] Szymanowsky,[5] and König,[6] the shaded parts of each illustration represent the defect, the dotted lines the incision, and the arrow indicates the direction in which a flap is to be displaced. The supplementary illustration indicates the appearance of the parts after union (from König).

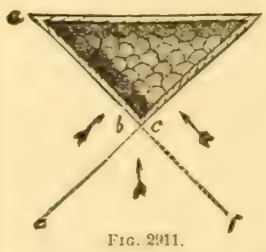


Fig. 2911.

(*a*) Small triangular defects may often be closed by gliding the angles of the wound toward its centre, and suturing the edges, which, when the integument is freely movable, can readily be brought in contact with each other in the form of a small tri-radiate star. If the defect is too large to be closed in this manner, one or two flaps may be easily prepared by carrying a straight or curvilinear incision from one or two angles of the triangular defect. Figs. 2901, 2902; 2903, 2904; and 2905, 2906 il-

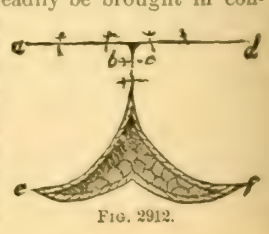


Fig. 2912.

lustrate the manner of sliding the flaps into position. Should the tension of the flaps be too great, liberating incisions may be made (Fig. 2903, *a*), the wounds thus left healing by granulation. If, in addition to the incision *c d*, a second incision (Figs. 2907 and 2908, *d e*) be made, parallel to the side of the triangle, a quadrangular flap will be obtained for the closure of the defect (Dieffenbach, blepharoplasty) and a small triangular wound left to granulate. If the first incision be made at an angle to the margin of the defect, and the second be made in the manner already described, the wound can generally be entirely closed by sutures (Figs. 2909 and 2910). When the triangular defect has a large base, as is often the case after removal of an epithelioma from the lower lip, straight or semilunar incisions carried from the apex in the direction of its sides (Figs. 2911 and 2912) will outline two flaps that, by sliding, can be brought into apposition along a line at right angles to the base of the

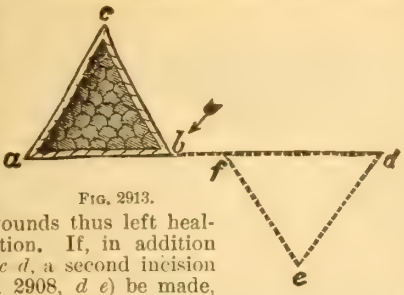


Fig. 2913.

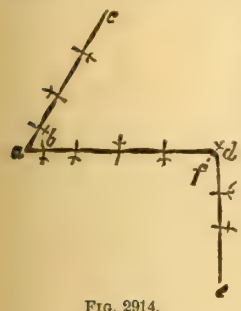


Fig. 2914.

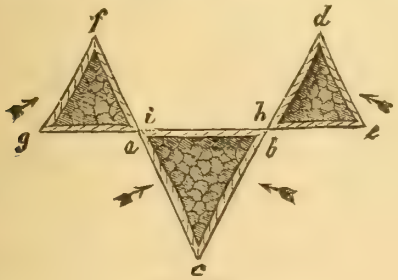


Fig. 2915

original defect. Burow, of Königsberg, has devised a method of closing triangular defects which, probably because it sacrifices healthy tissues, has not received the attention it merits. It is practised as follows: From the base of the defect, and continuous with it, a straight or curvilinear incision is made (*b d*, Fig. 2913), somewhat larger than the base of the defect. From the side opposite to this a triangular piece of integument (*f e d*), equal in dimensions to the defect, is removed. The flaps *c b d* and *a f e*, being then dissected up and glided along the

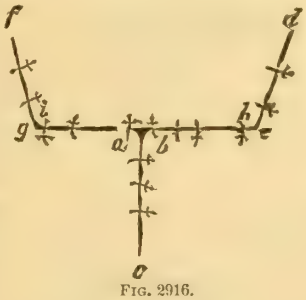
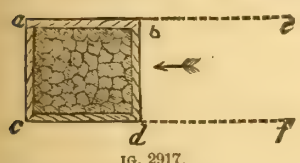


Fig. 2916.



Ig. 2917.

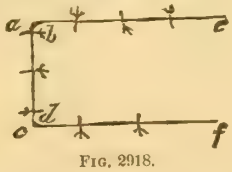


Fig. 2918.

base-line *a d*, readily close the wound. The line of suture is shown in Fig. 2914. If the defect is a large one,

Burow sacrifices two smaller triangles of healthy integument, as shown in Figs. 2915 and 2916.

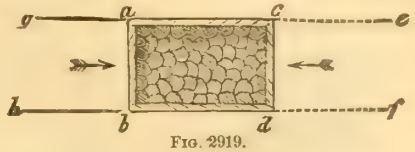


Fig. 2919.

(*b*) Quadrangular defects can, as a rule, not be effaced by suture alone. It is usually necessary to continue the incision in one or two directions, making one or two flaps after the method of Celsus (Figs. 2917, 2918, 2919, 2920). The tension on these flaps will be materially decreased by making angular or semilunar liberating incisions as indicated in Figs. 2921 and 2922. When the defect is a large one, smaller flaps may be obtained from three directions as illustrated in Figs. 2923, 2924. Quadrangular defects may often be closed by the formation of one or two flaps, which are turned into

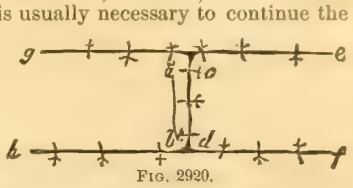


Fig. 2920.

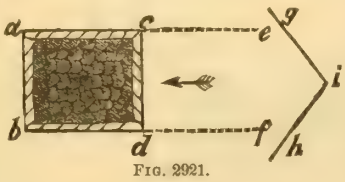


Fig. 2921.

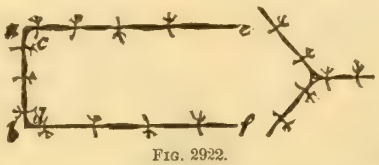


Fig. 2922.

their new positions around a broad pedicle (Figs. 2925, 2926, 2927, 2928, and 2929).

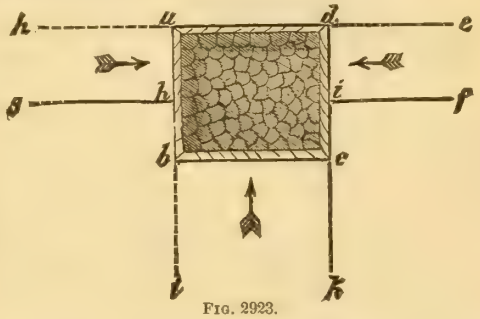


Fig. 2923.

(*c*) Oval and elliptical defects can generally be closed by a little traction along the line of their long axes. If

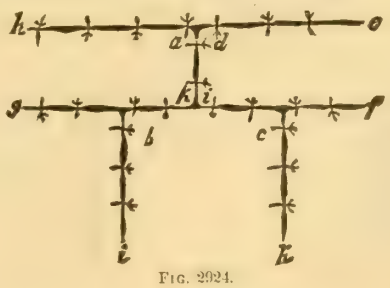


Fig. 2924.

the defect is broader, a liberating incision (Figs. 2930 and 2931) may be made, to overcome dangerous tension

in the sutures. Lisfranc closed defects by constructing two flaps from one side of the ellipse by an incision per-

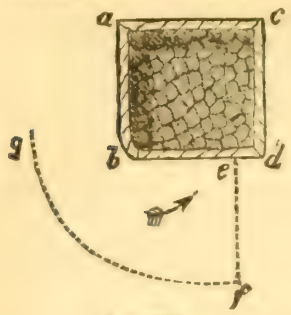


Fig. 2925.

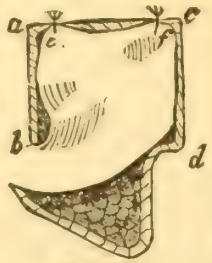


Fig. 2926.

pendicular to its axis (Figs. 2932 and 2933). If this does not suffice, two curvilinear incisions, *b d*, *b c*

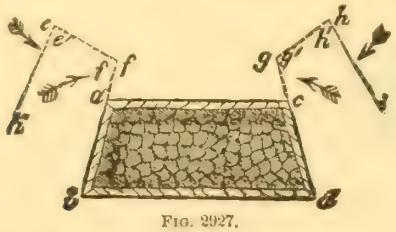


Fig. 2927.

(Figs. 2934, 2935), will facilitate the closure of the wound by two flaps that can easily be displaced to cover the wound. The flaps can also be so devised that they can be obtained from both sides, if the integument on one side be insufficient; by the incisions *a c* and *b d* (Figs. 2936 and 2937), two semilunar flaps will be formed that almost completely cover the defect. Weber's method of obtaining two flaps from one side, the one underneath the other, is shown in Fig. 2938. It is especially serviceable in defects of the lips.

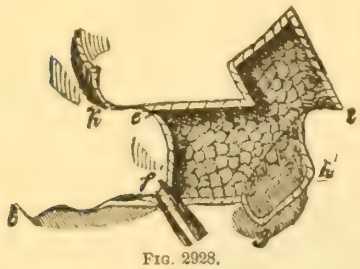


Fig. 2928.

(*d*) Circular defects, if not too large, are most readily overcome by converting them into oval or triangular wounds, preferably oval. If the defect is large, a semicircular flap must be obtained from the vicinity, and turned into the wound in the manner in which the quadrangular defect was closed.

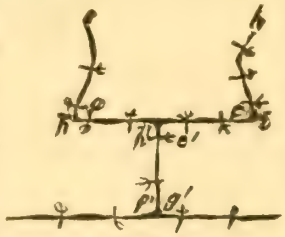


Fig. 2929.

Fig. 2930.

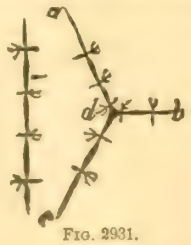


Fig. 2931.

It frequently happens that the integument in the immediate vicinity of the defect is unavailable for plastic purposes. This applies particularly to the extensive ravages made in the face by lupus and noma. After the cure of those diseases, extensive cicatrices often remain in the skin for a considerable distance around the defect. It then becomes necessary to go to a part farther removed from the latter for healthy skin. Thus the surgeon may be forced to fashion an eyelid from the skin of the temple, or a nose from that of the forehead (Indian method). In exceptional cases, it may even be deemed advisable to go still farther from the defect for a flap of healthy skin, as in the Italian method of rhinoplasty, in which the nose is formed from the skin of the arm. In the same manner, the place of a cicatrix from a burn of the wrist may be applied by skin taken from the abdomen, or, as Maas[1] demonstrated to the congress of German surgeons in 1886, otherwise incurable crural ulcers may readily be closed with a flap of skin obtained from the sound leg. In every case in which flaps are thus brought from a considerable distance, the part whence the integument is to be borrowed must be retained in relation with the defect for a varying length of time. In rhinoplasty after the Italian method, this is accomplished by appropriate bandages. In the case of Maas, the parts were retained in position by a plaster-of-Paris dressing until union was secured.

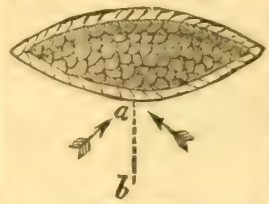


Fig. 2932.

Fig. 2933.

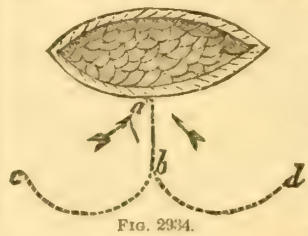


Fig. 2934.

Fig. 2935.

Nearly all plastic operations may be subdivided into a number of steps which refer, respectively, (1) to the preparation of the defect; (2) the formation and transplantation of a flap and the methods of assuring its vitality; and (3) the permanent and speedy closure of the wound.

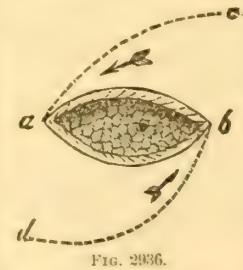


Fig. 2936.

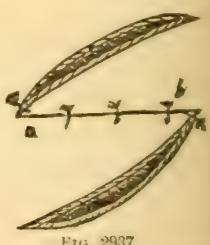


Fig. 2937.

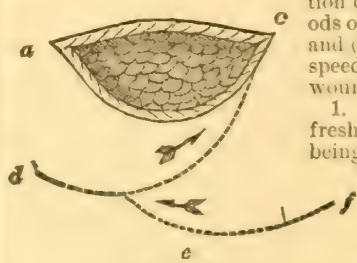


Fig. 2938.

1. The apposition of freshly wounded surfaces being practically an essential of success in plastic surgery, the first step in any operation of this kind is the freshening or vivifying of the defect. In recent traumatic defects, accidentally inflicted or produced intentionally by the surgeon in the removal

of a neoplasm, this step of the operation is sufficiently simple. In cases of accident, it is well to bear in mind that the wounds are often irregular in the extreme and their margins bruised, lacerated, and ill-suited to primary union. Here it is always essential to give the defect as regular an outline as may be, and to remove, with scissors or knife, the contused parts before attempting closure with or without the aid of a flap. When the defect follows the extirpation of a growth, and is to be closed at once by a plastic operation, every sacrifice must be made to procure radical removal of the neoplasm. The size of the defect is of secondary importance. Nevertheless, the incisions may be so arranged that the closure of the wound may be greatly facilitated. A glance at Fig. 2939 will make this sufficiently evident. In many cicatricial contractions and in congenital deformities, as in polydactylism, the preliminary step is also the formation of the defect for immediate closure. This is easily effected by the linear division of the cicatrix or connecting bands, and the restitution of the parts to their normal positions. When the defect has a free border, on the other hand, as in harelip, fistulæ, oral deformities, etc., the initial step of the operation is the paring or vivification of this margin, whereby the mucous, cutaneous, or cicatricial tissues are removed in such a manner as to procure a surface that is clean, smooth, and well adapted for primary union. Whether the paring be accomplished with scissors or knife, it is an essential of success that the border be removed in its entire thickness, since the presence of any undenuded spot in the line of proposed union destroys the possibility of a perfect result. To insure a broader surface for contact, and thereby greater probability of firm union, it is advisable to vivify the defect obliquely. This is particularly serviceable when, as in defects of the mucous membrane or of old cicatrices about the face, the margins are thin and would, if divided perpendicularly, offer a small surface for adhesion.

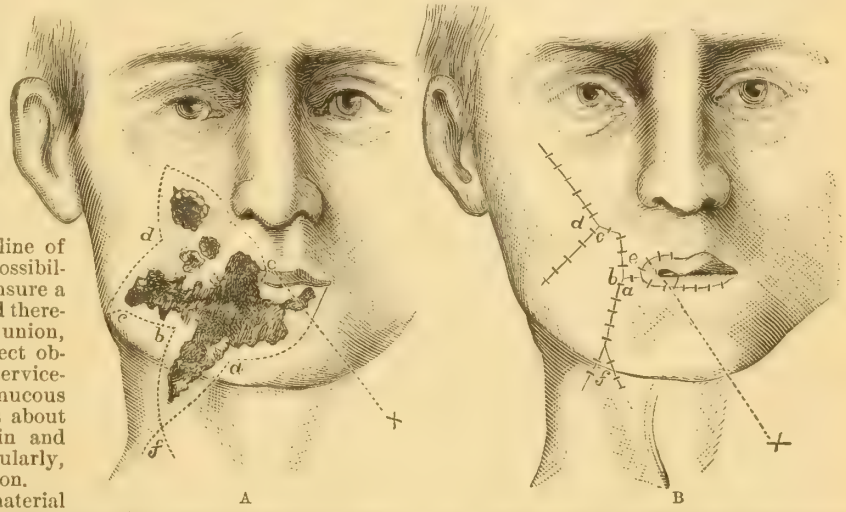


Fig. 2939.—Plastic Operation for Cancer of Lip. Showing (A) the proposed lines of incision, and (B) the completed operation.

2. The most available material should be selected in forming a flap; its size should be such that tension is nowhere exerted, and every precaution must be taken to insure a sufficient blood-supply. The shape and size of the flap vary according to the defect. It is to be remembered, however, that integumentary flaps invariably shrink after, and often before, their transplantation. The amount of retraction varies with the subsequent disposition of the flap. If a raw surface is brought in contact with a plane surface or denuded bone to which it can form adhesions, the danger of primary retraction is less imminent. Thus it is certain that a periosteal flap only slightly larger than a fissure in the palate will easily suffice for its closure, whereas almost twice the integument must be taken from the temple to form an eyelid. In all other cases it is well to make the flap one-fourth or one-third larger than the breach it is intended to cover. Operators of large experience can fashion the flap without a pattern. Dieffenbach always condemned its use, giving to the part to be formed ample dimensions at first, and remodelling it by supplementary incisions. It is certainly safer in all cases to make an accurate model of the part to be replaced, of paper, leather, adhesive plaster, or soft wax, which can be directly applied to the part from which the integument is to be taken, and serve as a guide to the lines of incision. The closest attention is required in the delineation and management of the pedicle. It should never, in a formal plastic operation, measure less than one-third of an inch in width, the probability of the survival of the flap being in direct proportion to the width of its pedicle and its capacity for arterial supply. As far as possible, therefore, the flap should be so outlined that the incisions will not necessitate the division of large arterial twigs. For the same reason, excessive torsion of the pedicle must be scrupulously avoided. Verneuil[8] aptly proposes the name of hilum for this portion of the flap, since this term expresses its important function in the nutrition of the flap.

Into the composition of the flap there should enter, as far as possible, tissues histologically analogous to those of the part to be repaired. Skin should therefore, as a rule, be replaced by skin, and mucous membrane by mucous membrane; although the possibility of the convertibility, in the course of time, of the one into the other, should be borne in mind. Thus the integument may, without difficulty, be made to substitute the mucosa of the bladder or of the nares. Mucous membranes, however, do not, as a rule, assume the characteristics of common integument, although that of the vagina forms an exception. The mucous lining of the nares, of the lips, of the nose, and of the bladder may be exposed for years without sensibly approaching the appearance of the skin. When skin enters into the composition of a flap it should, as far as may be, resemble that of the part lost. The delicate integument of the eyelid would not be suitable for repairing defects of the upper lip, nor would the appearance of the nose be improved by a patch of hair on its end. Above all things, the integument to be utilized for the flap should be healthy and freely movable.

The incisions being made, the integument, together with more or less of the subcutaneous cellular tissue, is to be dissected up from the underlying structures. The thickness of the flap should always be commensurate with its other dimensions. Large and thin flaps often succumb to defective nutrition. The subcutaneous cellular layer is an essential of all large flaps, since it is the medium through which the skin receives its nutrition. An excess of adipose tissue, however, is an element of danger to the vitality of the flap. It has been claimed that muscular tissue should not enter into the composition of a flap when it can be avoided, on the ground that muscle without function is speedily converted into fibrous tissue, and the presence of this cicatricial tissue may become an important factor in marring the final result in many plastic operations.[9] In those upon the face muscular elements cannot be excluded, since they are directly inserted into the skin; nor would their exclusion be advisable, since without them the mobility of a newly formed lip or eyelid would be out of the question. The periosteum may also, in exceptional cases, be included in the flap in plastic operations. B. v. Langenbeck[10] and Ollier[11] have thus sought to utilize the osteogenetic function of the periosteum in rhinoplasty and uranoplasty, in the belief

that the new bone developed by it would give the normal resistance to the repaired part.

Verneuil, Sédillot, and others question the utility of this procedure, believing, and in some instances with good reason, that the inclusion of the periosteum in a flap is an element of danger to the vitality of the part whence it is taken, and that it increases the probability of sepsis. Regarding operations on the palate, the danger of necrosis after periosteal denudations is certainly theoretical. Langenbeck,[12] who has probably operated oftener than anyone else for cleft palate, by this method, has never seen the bone exfoliate. He has, however, noticed such an accident after rhinoplasty. Nor can there be any question as to the formation of new bone from periosteal flaps. In every congenital defect of the palate operated upon by this distinguished surgeon which was under observation more than four weeks after uranoplasty, the formation of new bone was confirmed. It begins about the third week, and is completed about the fourth week, although it subsequently gains in solidity. So far as time is concerned, the periosteal regeneration of bone after plastic operations may then be said to be chronologically analogous to that which takes place in the repair of fractures. Nor any more than after fractures is there any danger that the newly formed bone will subsequently undergo retrograde changes.

To increase the thickness and, therefore, the vitality of large flaps, and at the same time approximate the repaired part to the normal structure and function, very thick, and even duplex flaps must often be formed. Thus, while a large defect of the lower lip may be covered with a flap from the neck, the new lip will be thin, devoid of muscular fibre, and, therefore, of movement, and soon becomes firmly attached to the lower jaw. It is preferable, therefore, when possible, to make the flaps of the entire thickness of the cheek, covered with skin and mucous membrane, which, when brought into position, subserve in the best manner possible the purposes of the part destroyed. Or it may be practicable, if it be deemed best to use the flap from the chin, to reflect the mucous covering of the alveolar border for a lining to the cutaneous flap. As will be seen in operations for rhinoplasty and extrophy of the bladder, this doubling of the flap may be practised with two folds of skin, the lower of which subsequently becomes converted into mucous membrane. For this method Ad. Richard,[13] in 1854, proposed the term "autoplastie par doublure."

3. The transplantation and permanent attachment of the flap constitute the last steps of formal plastic operations. At present all authors are agreed that, save in exceptional cases, the fixation of the flap should at once follow its formation as soon as all oozing has ceased. Tagliacozzi, however, in his rhinoplasties, allowed the undersurface of the flap, taken from the arm, to suppurate before fixing it in the new position. Graefe, on the other hand, successfully practised fixation while the surfaces were fresh. In very rare cases the old operation may be followed with good results. Thus the author, in 1876, saw Billroth close a gastric fistula with a flap that had been lifted from its surface one week before fixation, the reason given for this being that the suppurating surface would be less affected by the deleterious influence of the gastric juice than one recently prepared.

In 1854 Roux was compelled by circumstances, in a defect of lip and chin, to resort to a practice which some writers have sought to elevate into a special method, that by successive migrations. "It consists in fixing a flap temporarily in a new position, from which, after the lapse of several weeks, it is removed by a second operation to a part nearer the defect, where, after a number of migrations, it is finally deposited.[14] Buck has resorted to a somewhat similar expedient in extensive deformities of the face. It is only in these that it is ever practicable.

To facilitate the transplantation of a flap and to relieve tension, liberating incisions are often required. Thus in hare-lip, success is not generally attainable without freely liberating the segments of the lip which are more or less bound down to the maxilla. Such liberating incisions cannot always be concealed, as in the instance cited. They should then be made as small as consistent with the effect desired, and in the manner indicated (*g i h*, in Fig. 2921).

To close the wounds resulting from these liberating incisions is permissible only after the defect has been covered and when it is evident that closing the secondary incisions does not cause traction on the more important line of sutures closing the primary wound. Where there is any doubt, it is best to leave the liberating incisions unsutured, and the wounds to heal by granulation.

The fixation of the flap by sutures forms the final step of the plastic operation. The care and accuracy in apposition of the raw surfaces observed in other surgical procedures are particularly demanded here. The absence of blood within the wound is an essential to success. Hence Dieffenbach, Lisfranc, and others often postponed fixation for two or three hours until all oozing had ceased. As Verneuil justly says, while admitting the value of this method in former times, "in our day operations are generally made under anæsthesia, from which, when the patients awake, they like to believe that the operation is completed; hence it is a source of great suffering to mind and body to delay the completion of the operation." In closing the wound the continuous or interrupted suture may be employed. As a rule, small needles should be used. The angles of the surfaces are first approximated. While the number of sutures must be sufficient for accurate apposition and the avoidance of wrinkles in the flap, an excessive number is doubtless harmful, since every suture, however fine, interferes in a measure with the circulation in the part, and every suture may become a source of suppuration. When considerable traction must be made to hold the flap in position, one, or even two deep sutures of heavy silk may profitably be inserted far from the edges of the wound, as after amputation. In this way the tension on the more numerous superficial sutures is effectually removed. The material used for sutures varies according to the length of time they are to remain. In plastic operations about the face an iron-dyed silk probably answers the best purposes. These sutures can be removed, a few at a time, in from forty-eight hours to five or six days after the operation, according to the union obtained. When it is desirable to retain the sutures longer, as in operations on the vagina, silver wire is to be preferred, since metals produce vastly less reaction in the tissues than silk. When a large defect has been covered by a flap, there still remains the wound left by the removal of the latter. In many instances, as will be seen from the illustrations, this can be entirely closed by suture. In all cases, however, it can be so materially diminished in size that only a comparatively small surface will be left to heal by granulation. Its presence will in no way interfere with primary union of the sutured parts.

Regarding the after-treatment, little need be said. The wounds are frequently in a position where antiseptic measures cannot be successfully carried out; as, about the lips or nose. In these cases dry cotton compresses, held in position by properly adjusted bandages or adhesive strips, will go far toward supporting the parts, and assuring primary adhesion. Where practicable, antiseptic precautions should be taken. Wounds made for plastic purposes should be frequently examined to determine the condition of the parts, and particularly if a flap has been utilized. Immediately after its application a flap is cool, pale, and insensitive. Within from twelve to twenty-four hours, as circulation is established, its temperature rises, and a marked redness distinguishes it from the integument surrounding it. This redness easily yields to a bluish discoloration and excessive swelling, both indications of venous stasis, which, if not checked, often leads to sloughing. Loosening one or two sutures, or scarification of the flap itself, may avert such a result. If suppuration under the flap is suspected, the most dependent sutures must be removed for proper drainage. With proper precaution the presence of suppuration does not necessarily entail failure of the operation, since the flap may be held in position with small strips of adhesive plaster or by a number of sutures inserted at its salient points.

Supplementary treatment and even operations are often necessary after complete closure of the wound. Thus constant attention must be given the nostrils after rhinoplasty, the lower lip after cheiloplasty, lest the former close, or the latter become adherent. Or it may be that the contraction of the flap has not ensued to the degree anticipated, and the newly formed organ presents wrinkles of redundant skin. In the same way, the pedicle of a flap which has subserved its purposes must be excised if at all prominent. Such redundant masses can always be easily removed by oval incisions. In the case of the pedicle, several months must elapse before its excision is even to be thought of. A premature attempt in this direction of improving the result of a plastic operation may easily annul the advantages already obtained.

As has already been observed, every case requiring a plastic operation is a law unto itself. The more complicated the defect, the greater the study and practice required in overcoming it. When the destruction of tissue has been very extensive, as in noma, lupus, or burns, a single operation rarely suffices. Three, four, and even more operations may be necessary before the appearance of the face is in a measure restored. In these complicated cases, too much should not be attempted at one time, and an interval of from one to six months may often be advantageously observed between the different operations. It is in this way that the most successful workers in this field have, by repeated efforts, often extending over a period of two or three years, given a new life to individuals who, from very extensive destructions of prominent parts of the face, have been objects of disgust to themselves and of horror to those with whom it was their misfortune to come in contact.

Blepharoplasty.—The operation necessary for the partial or total construction of an eyelid is termed blepharoplasty. The conditions demanding it are disfiguring cicatrices which, by everting the lids, endanger the functions of the eyeball, and ulcerations or neoplasms which demand the sacrifice of the lid for the safety of the individual. When an eyelid is formed for cosmetic purposes alone, the result is often not very satisfactory, at least to the patient. The dangers of failure are, of course, considerably increased if the tarsal cartilages have been destroyed or the orbital margins seriously involved. The first step of the operation, irrespective of subsequent procedures, is the excision of the diseased lid, or the division of the cicatricial bands producing eversion. In the latter instance the free border of the lid can usually be saved. In the former the reverse obtains, as a rule. In this preliminary operation Dieffenbach sought to give the defect a triangular, Fritze a somewhat oval, and Knapp a quadrangular shape, the breach in each case being closed by a flap of similar shape.

Dieffenbach's method is diagrammatically shown in Fig. 2907. From the basal angle of the triangular defect an incision is made in the continuation of the base-line, and of equal length ($c\ d$); a second incision ($d\ e$) is then made parallel to the outer side of the triangle. Thus a flap is outlined which, when raised, can, by gliding, be readily brought into the position of the defect, leaving but a small defect to be closed by granulation. This objectionable feature can be obviated by making the incisions in such a manner as to make the external angle of the flap more acute. The wound can then be entirely closed (Szymanowsky, Figs. 2909, 2910). In 1829 Fricke devised a blepharoplasty particularly adapted for the upper lid, but also applicable to defects of the lower. The method consists in giving the defect an oval outline. A flap of similar form is then taken from the temple if the upper, and from the cheek if the lower, lid is to be formed. In either case the flap must be twisted around the pedicle at an angle of ninety degrees before it can be brought into position and retained by sutures. In this method there is no difficulty in closing the secondary wound at once. For the closure of quadrangular defects of the eyelids Knapp advises the formation of two quadrangular flaps, one from each side of the breach. After being raised they are brought into contact with each other along their narrow edges (diagrammatically shown in Figs. 2919, 2920). The advantage of this method is in the absence of cicatricial contraction in a downward direction, and the avoidance, therefore, of eversion of the new lid. Burow's triangular (Fig. 2913) method may also occasionally be used to good advantage in small defects involving the skin alone. When an entire lid is to be reformed, the excessive sacrifice of skin would preclude the usefulness of this method.

In recent years there has been a manifest tendency in many cases to supplant the plastic methods described by the grafting of large portions of skin removed from the inside of the arm or of the trunk. If either of the methods above mentioned fails, the deformity resulting from the operation is greater than it was before, and a cicatrix, often disfiguring, is left in the situation whence the flap was taken. In 1876 Wolff and Wadsworth, and one year later Aub, succeeded in ingrafting flaps measuring two and a half inches in length and one and a half inch in width into the defects. Only the skin was used in these operations, and the flaps were made large enough to allow fifty per cent. for shrinkage. In Aub's cases, after the sutures were applied, gold-beater's skin was used to cover the flap, which was then supported in its position by a compress-bandage. To give greater probability of success by complete rest of the part, it is advisable to close the palpebral fissure by a few strong sutures before resorting to the plastic operation proper. This method of transplantation is particularly suited to cases of burns when the skin alone is involved, and the tarsal cartilages and lid-margins are unimpaired. When a portion or the whole of a lid must be removed in its entire thickness, as for neoplasms, the methods of Dieffenbach, Szymanowsky, or of Fritze, must still be resorted to for the closure of the defect.

Cheiloplasty.—The reconstruction of a lip after its partial or total destruction by injury or disease is termed cheiloplasty. In the preponderance of cases it is performed for epithelioma, and for the most part, therefore, is practised on the lower lip. The upper lip, also, at times is destroyed by noma, lupus, burns, or wounds, and thus becomes the subject of plastic repair. Except in cases of epithelioma these operations are particularly complicated, and tax the ingenuity of the surgeon through the involvement and distortion of the angle of the mouth and of more or less of the integument of the cheek or of the nose. Owing to the great variety displayed by individual defects of the lips, many methods have been devised for their relief. Only those are very serviceable in which a flap covered by integument without and mucous membrane within can be utilized. In all other methods, although at times they must be followed, the flap speedily becomes adherent to the maxilla, immovable, useless for mastication, and incompetent to retain the saliva. Another defect in the immediate result that appertains to almost all methods is the disparity in size between the sound and the reconstructed lip. The latter usually being smaller, the other projects far beyond, while the mouth presents an unnaturally contracted appearance. Still, this abnormal condition is recovered from after the lapse of a few months, the mouth being spontaneously remodelled.

In all cheiloplasties it is essential that the flap be obtained from the immediate vicinity of the defect, since failure is certain to follow any attempt to obtain it from a distance. The mobility of the parts during mastication is such, that fixation of the arm cannot be maintained for a sufficiently long time or accurately enough to prevent the loss of the flap.

Cheiloplastic operations may be divided into: (1) Those that affect the lower lip; (2) those that affect the upper lip; and (3) those that affect the angles of the mouth, or the mouth as a whole (stomatoplasty).

1. Since the lower lip is repaired most frequently for epithelioma, the surgeon can often shape the defect in a way to facilitate its closure. If the neoplasm involve only a slight extent of lip, it should be removed by a V-shaped incision, when, ordinarily, no difficulty will obtain in closing the gap with deep sutures, even if the en-

tire thickness of the lip has been removed. When the disease, however, covers a large area but is superficial, removal by a curvilinear incision is preferable, since the defect thereby produced will readily be supplied without plastic procedures. When the entire lip is involved, in thickness as well as in height, rectangular or curvilinear incisions alone are serviceable for the removal of the neoplasm.

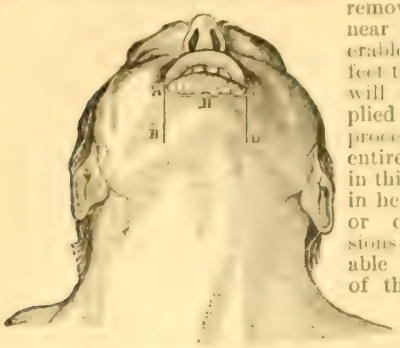


Fig. 2940.

When, as is often the case, the disease involves the angle of the mouth, the incisions must necessarily be more complicated and altogether regulated by the extent of the disease. Even in extreme cases the gap can often be closed by a combination of V or W-shaped incisions. Weber mentions a case in which the disease was very extensive. When circumstances compel the surgeon to borrow the material for the flap from the chin or neck, the methods of Chopart, of Lisfranc, or of Berg may be adopted. In Chopart's operation the diseased tissue is included between two parallel perpendicular incisions carried over the chin and on to the neck as far as the hyoid bone, if necessary (Fig 2940). (Nélaton.) When the diseased part is then removed by a horizontal incision, there remains a quadrangular flap (B H D) which, when dissected up, is brought by a process of gliding to the level of the labial commissures, where it is retained by sutures. Lisfranc preferred to remove the neoplasm by a curved incision, from the centre of which (Fig. 2941)

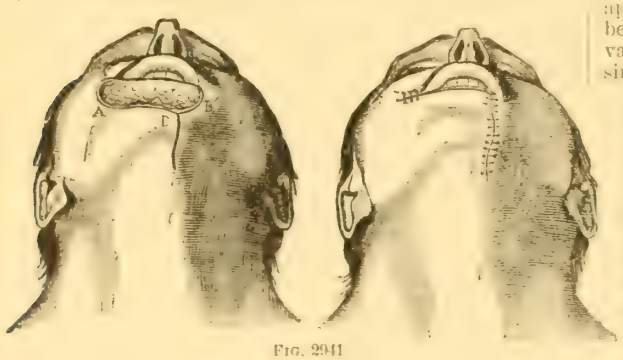


Fig. 2941

a perpendicular cut of greater or less length, carried downward, outlined two flaps which, when detached, were brought into position. Berg also gave the defect a curvilinear outline, but preferred to use a single flap from the chin and side of the neck. Fig. 2942 shows the manner of delineating the flap, bringing it into position, and of closing the primary and secondary wounds. If the upper margins of the flap be covered, from each angle of the mouth, by a portion of the vermilion border borrowed from the upper lip, the result will be excellent, although the oral aperture may temporarily be materially decreased in size. To accomplish the same end Serre, in an extensive epithelioma of the lower lip, practised Chopart's operation, preserving the mucous membrane of the lip for a covering to the flap. It is almost needless to say that it is only in exceptional cases of very superficial neoplasmata that this method is at all applicable.

When the defect after removal of an epithelioma is triangular, with base involving the greater part of the lip, the operations of Dieffenbach or Malgaigne may be profitably resorted to. That of the German surgeon consists in making an incision on each side from the angle of the mouth toward the masseter and in the line of the labial fissure. The length of the horizontal incision is half that of the base of the defect. The quadrilateral flaps thus raised are brought together in the median line by their internal borders. The operation of Malgaigne differs from this in that he refrains from the use of the perpendicular incision. To overcome the redundancy of the upper lip, a triangular portion may be excised (Fig. 2943). In either operation the new lip can easily be lined with mucous membrane, if that of the cheek be divided at a higher level than the integument in the horizontal incisions from the oral angles. In cases in which the defect is triangular and shallow its closure by later incisions, after Syme, presents many advantages. In it the incisions are prolonged downward and outward for an inch, whence they are carried upward and outward for a varying distance. The flaps thus outlined are dissected off the bone and brought together in the median line. The mucous membrane and skin are stitched together along the upper edge, and the triangular interval

Fig. 2942.

on each side left to heal by granulations. To facilitate union of the flaps, the tip of the spur left below the apex of the defect may be removed after the flaps have been raised (Fig. 2944). (Nélaton.) The very great advantage of this method over those preceding it is that, since the integument covering the chin is not disturbed, the flaps cannot sink or be drawn downward toward the neck, and the new lip will maintain its original height. Quadrangular defects of the lower lip may be successfully overcome by resorting to two rectangular flaps taken from the chin or from the side of the chin. Sédillot (Fig. 2945) made the flap at right angles to the line of the mouth from the side of the chin, Bruns preferring to make them obliquely and from the cheek. When the flaps are raised they are turned on their respective pedicles, when their inner boders meet in the median line. When circumstances permit of a choice between the methods of Sédillot and Bruns (Fig. 2928, diagrammatic), the former should be preferred, since in the latter there is considerable danger of traction on the cheeks and consequent deformity. The operation of Sédillot also offers a better opportunity for covering the upper edges of the flaps with part of the vermilion bor-

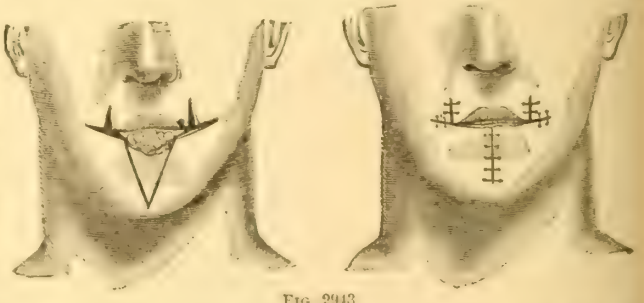


Fig. 2943.

der of the upper lip. When this is severed for half an inch or more on each side from the upper lip, the flaps forming the lower lip can be almost entirely covered.

The practice of Schuh to tattoo the edge of the lip for cosmetic purposes has probably never been followed by other operators. In 1869 Langenbeck first practised a cheiloplasty which has gained many followers in Germany. In this method the diseased lip is removed by a

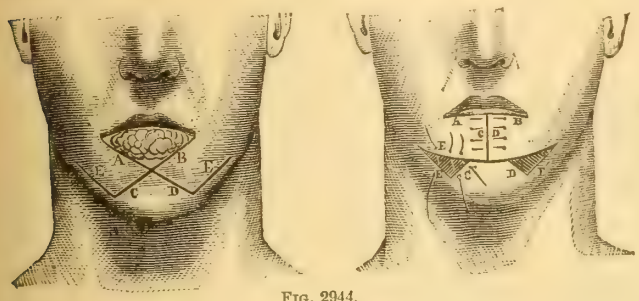


Fig. 2944.

curvilinear incision (Fig. 2946). A flap is then prepared from the integument of the chin (1) the base of which is on the side of the oral angle. The free extremity of the defect is not directly under the oral defect, but separated from it by a triangular portion of skin (2). Both flaps being raised, the lower is elevated into the defect, while the other is utilized in closing the breach below (Fig.

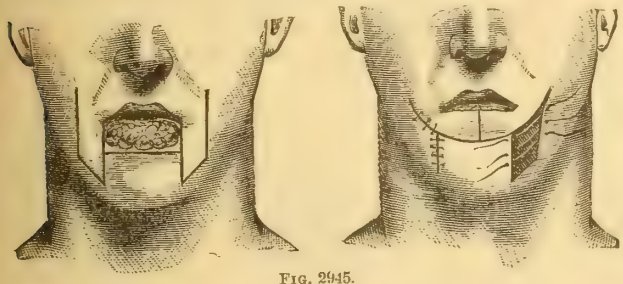


Fig. 2945.

2947). The presence of the spur prevents the sinking of the lip.

When desirable, the upper edge of the flap may be covered with a portion of the mucous border of the upper lip. Gurdon Buck ("Repar. Surg.," p. 22), and Estländer (*Arch. f. Chir.*, xii.), closed defects of the lower lip with flaps taken from the upper. Buck, after removing the growth by a V-shaped incision, or by one horizontal and two perpendicular incisions in more complicated cases, brought the sides of the gap together directly; or in the case of the quadrangular defect, by forming two horizontal lateral flaps which were secured to each other in the median line by pin-sutures. After closure of the wound had been effected, a secondary operation was performed to transfer the redundant tissue of the upper to the deficient lower lip, and thus to restore the symmetry of the mouth. This operation is performed as follows: A point is selected about a finger's breadth below, and a little without the oral angle on each side, and marked by the insertion of a pin through the skin. Another is inserted on each side at the junction of the vermilion border of the upper lip with the skin, about one-fifth of the distance from the angle of the mouth to the median line of the lip, and a third pin on each side is inserted into the integument of

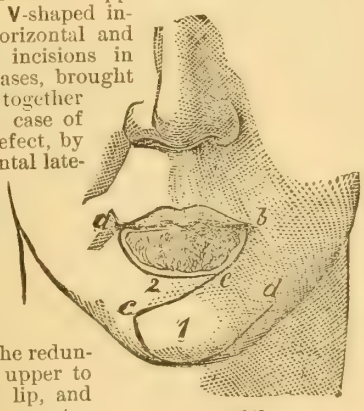


Fig. 2946.

the cheek, about an inch and a half above and without the angle of the mouth. The points indicated by the first and third pins are then to be united by an incision through the entire thickness of the cheek, and in like manner the points indicated by the second and third pin. A triangular flap is thus formed, with its base toward the angle of the mouth.

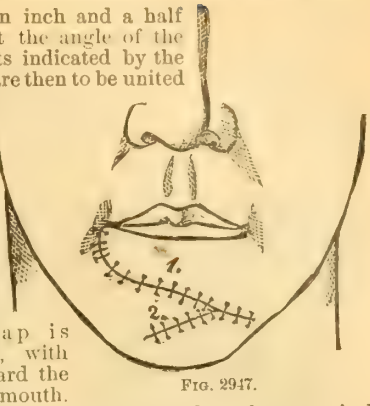


Fig. 2947.

From the point indicated by the first pin, a vertical incision is now made to the base of the jaw. The integument in this region being in a state of great tension, the edges recede and form a space for the reception of

Fig. 2948.

the triangular flap, with its apex toward the base of the jaw, and its base, including a portion of the vermilion

Fig. 2949.

border of the upper lip, supplying the deficiency of the corresponding side of the lower lip. When the operation on both sides is completed the configuration of the mouth is nearly normal (Figs. 2948 and 2949, from Buck).

Estlander's operation differs from that of Buck in that the outer incision is curvilinear, and that the plastic operation at once follows the extirpation of the tumor.

(2) In reconstructing the upper lip, the operator has

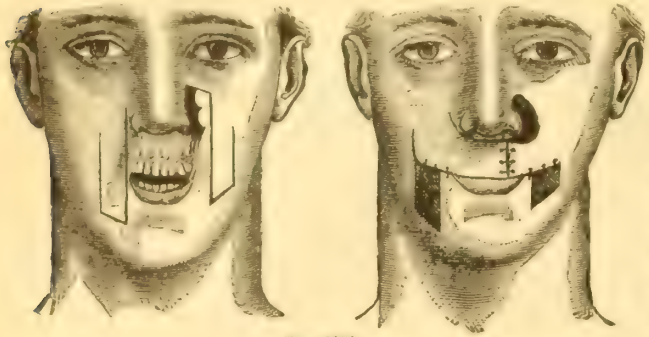


Fig. 2950.

the choice of a number of methods. In cases of total deficiency, the method of Bruns, already referred to (Fig. 2927), yields excellent results. Berard utilized two lateral flaps from the cheeks, including them between parallel horizontal incisions, carried outward to the masseter, the upper from the angle of the nose, the lower from the angle of the mouth. The flaps thus formed are brought into position by gliding, and united by pin-sutures in the median line. A better operation for severe cases is that of Sédillot (Fig. 2950), which is performed as follows: On each side of the oral angle a quadrilateral flap, of the width and half the length of the lip, is outlined by two perpendicular and one horizontal incision on each side. The inner of the perpendicular incisions is carried higher than the outer. When the flaps have been thus outlined, they are raised from the underlying tissues. The entire thickness of the cheek is included in the flaps, which are therefore lined with mucous membrane. When the flaps are brought into position, their lower borders meet in the median line, the inner borders are sutured to the upper margin of the defect beneath the nose, while the outer borders assume the position of the free border of the lip. With a little traction the mucous membrane and the integument of this border can be united by a number of very fine sutures.

When the defect of the upper lip is central and not very extensive, the method of Dieffenbach presents much to recommend it. It consists in transfixing the cheek on

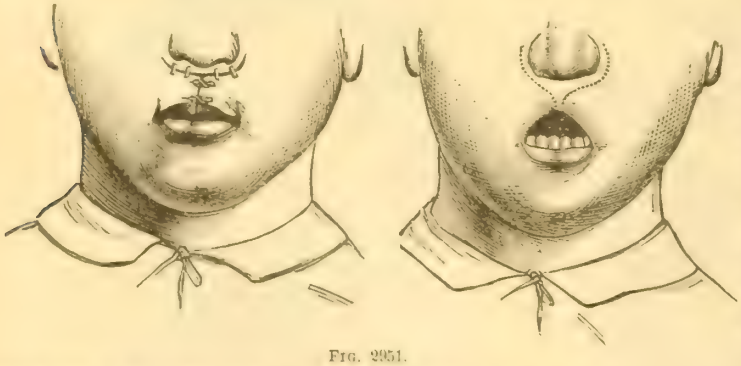


Fig. 2951.

each side of the angle of the nose, and forming a flap on each side by a curvilinear incision (Fig. 2951). When these flaps are raised from their attachments to the alveolar border, they are easily brought into apposition by their internal margins in the median line. The method of fixing the flap beneath the nose is also shown in the illustration. The advantage of this method, when it is applicable is in the greater height given by the curvilinear incision to the flap in the median line, and in the fact that its free border is naturally covered by mucous membrane.

Ledran and Roux utilized one-half of the lower lip for repairing deformities in which the outer half of the upper lip was lost. Both of these operators transplanted a quadrangular flap with its pedicle outward. This method was greatly improved upon by Buck, who, placing the pedicle internally, temporarily reduced the length of the oral fissure. This method of operation is shown in Fig. 2952. The extremity of the lower lip, where it joins the right cheek, is divided through its entire thickness at right angles to its border, and for a distance of an inch (*a b*). A second incision is made from the end of the first parallel to the labial border, for a distance of one inch and a half (*b c*); from *c* a short incision (*c d*) is made toward the free border of the under lip, and parallel to the incision (*a b*). The quadrilateral flap thus formed from the lower lip is now turned upon its pedicle to meet the remaining portion of the upper lip, to which it is attached by its free extremity (*a b*). Fig. 2953 shows the result of this operation, and the method of overcoming the deformity of the angle of the mouth which results.

3. Stomato-plasty.—Destructive ulcerative processes about the lips and angles of the mouth occasionally give rise to deformities which, by greater or less closure of the oral aperture, interfere with the process of mastication, and eventually threaten the life of the individual. In extreme cases the labial fissure is contracted to a degree which compels the patient to live on liquid food alone. Until Dieffenbach's remarkable contributions to plastic surgery, it was customary to treat these cases by the insertion of a seton of silk or of wire. As in cases of syndactylism treated in this way, the result was generally unfortunate. Dieffenbach's method, which, unless the mucous membrane is everywhere adherent to the alveolar border, is as a rule successful, and is performed as follows: On each side of the contracted oral orifice a narrow triangular strip is excised from the skin. The base of the triangle is internal, its rounded apex external, and at the point where the angle of the mouth is to be. The excised triangular portion should include everything down to the mucous membrane, which remains intact in the floor of the wound. The mucous membrane is then divided in the floor of the triangle, thus forming an upper and a lower flap, which, when everted, will clothe the free borders of the new lips and meet externally at the angle of the mouth. The excess of mucous membrane is thus utilized in forming the vermilion borders of the lips.

Fig. 2952.

Buck's method of stomato-plasty, already alluded to, differs somewhat from that of Dieffenbach. He makes an incision along the line of the vermilion border, circumscribing half of the mouth, and extending to an equal distance above and below (Fig. 2953, *a b*). This

incision should divide the skin and subcutaneous tissue, but not involve the mucous membrane. A sharp-pointed double-edged knife is then inserted between the skin and mucous membrane, and these parts separated from each other as far outward as the point proposed for the angle of the mouth. The skin alone is then divided with strong scissors along the line which is to separate the upper from the lower lip (*c d*). The mucous membrane is next divided along the same line, but not so far outward, the difference in the length of the division of skin and mucous membrane being a little less than the thickness of the cheek. The angles at the outer ends of the two incisions are then carefully united by a single thread suture, and the operation is completed as in Dieffenbach's method. To accommodate the mucous membrane to the borders of the lips, thin slices of integument must, as a rule, be pared from the upper and lower borders of the wound.

FIG. 2953.

RHINOPLASTY.—The nose gives character to the face by its prominence and central position. Its absence or deformity is therefore more naturally observed than that of any other feature. It is only through familiarity with the nasal defects caused by syphilis or lupus, that one without unusual vanity can understand why Tagliacozzi devoted a special chapter to the "dignity of the nose," and can appreciate the saying of Lavater, that "a beautiful nose is worth a kingdom." Passion, disease, love of honor, and punishment for crime, have all, in times past, contributed to producing the greatest facial disfigurements by attacking the nose. Hence the surgical art was taxed early to repair the deformed part, and rhinoplasty became the foundation of plastic surgery in general. In previous centuries, when the loss of a nose was a punishment for crime, or was voluntarily inflicted to preserve virtue, rhinoplasty was doubtless a more common operation than now. Sixtus V. freed Rome of its bandits by cutting off the noses of all that were caught. The Abbess of St. Cyr disfigured herself and forty of her nuns in the same manner, to preserve their virtue when the Saracens raided Marseilles. In our more civilized times, nearly every case requiring rhinoplasty results from disease; although, in exceptional instances, a vicious bite or, as in Germany, a duel, is the cause for plastic interference.

Notwithstanding the accumulated experience of generations of surgeons, and the closest attention to every technical detail that could further the results of rhinoplasty, it must still be admitted that the best nose that can be formed by a plastic operation is hardly as presentable as the natural feature that is even far removed from the ideal. It is far preferable, however, to the artificial nose formed of vulcanized rubber, and retained in position with collodion or a spring. After a rhinoplasty that is at all successful, the catarrhal condition of the nose and pharynx is improved, the sense of smell and of hearing return, and the irritating cough which so often is present in extensive defects of the nose rapidly disappears. A successful rhinoplasty is productive of benefits which cannot follow the use of any nose fashioned by prosthetic skill.

Since the time of Dieffenbach, rhinoplastic operations have been divided into the total and partial. It is particularly in partial rhinoplasty that great strides have been made within the last half century. To consider systematically the different operations for repair of the nose, nasal deficiencies, according to Gross, may be classified as follows: 1. Loss of the entire organ, bones as well as soft parts. 2. Destruction of the whole or greater portion of the cartilages, the bridge remaining intact. 3. Mutilations of the tip, as when a small piece is cut or bitten off, including a part of the wings. 4. Loss of one wing, either alone or together with the nasal column. 5. Perforation of the nose, either on top or at the side; in the latter case with or without participation of the cheek. 6. Sinking of the organ from destruction of the cartilaginous septum of the nose, the soft structures being but little, if at all, affected. 7. Loss of the column. 8. Mutilation of the nose and upper lip, or the nose, lip, and cheek.

When the entire nose has been lost, there is generally a large pyriform aperture which allows free inspection of the nares and naso-pharynx. For the alleviation of this condition, it is always best to fashion the nose from a flap taken from the forehead, by what is known as the Indian method. Before proceeding to a total rhinoplasty, the defects should be covered with a model of clay, wax, or dough, which should approximate as much as possible in size and form an ideal nose. Over this is accurately fitted a piece of soft leather or mole-skin plaster, the lower margin of which is pressed into the nostrils and made to cover the nasal column. The shape of this piece of leather or plaster, when removed from the model, is pyriform, with its base below and apex above. A second piece of leather or of plaster, one-third larger in all its dimensions, should then be prepared from the first, the increased dimensions being allowed for shrinkage. The model thus prepared, when applied to the forehead, is shown in Fig. 2954 (Linhart). The plastic operation proper is preceded by freshening the edges of the defect. This must be done as liberally as possible, to procure a wide surface of contact for the flap. The vivified border should everywhere measure one-third or even half an inch in width. When this step of the operation is completed, the leather or mole-skin model is applied either perpendicularly or obliquely to the forehead. The latter is probably the better method, since less rotation of the flap is required to bring it into position. When the forehead is decidedly low, no alternative is presented to the operator, since the central excision of the flap would necessitate the inclusion in it of a considerable portion of the hairy scalp. König and others maintain, however, that the frontal scar resulting from central location of the flap is less disfiguring than that which follows the other procedure. Lisfranc, Linhart, and v. Langenbeck prefer to take it from the side. When the operator has applied his model in the desired position, an incision down to the periosteum is carried around it. The incision, as shown in the figure, begins at the right margin of the defect, is carried obliquely over the right eyebrow, and descends on the left side of the model, terminating above the internal end of the left brow. In terminating this incision, it is essential not to interfere with the angular artery, since the vascular supply of the new nose, in a large measure, depends upon the integrity of this vessel. The pedicle left between the ends of the incisions should measure from one-half to three-fourths of an inch in width. The flap thus outlined is now rapidly raised, being made to include, besides the integument, the aponeurosis and fibres of the occipito-frontal.

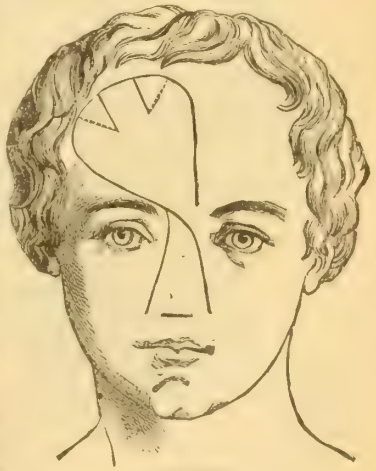


FIG. 2954.

In the lower part of the flap the periosteum can safely be included. Langenbeck included it in the entire width of the flap, except in the parts of which the column and alæ of the nose were to be formed. When hæmorrhage from the edges and raw surface of the flap has been controlled, it is rotated into position in such a way that the raw surface looks backward, and its base naturally comes in contact with the freshened margin of the upper lip. The next step of the operation is the formation of the septum and alæ. This is readily accomplished by two oblique incisions, one inch in length (dotted line in Fig. 2954), which, running toward each other, are separated at their central ends by an undivided interval nearly an inch wide. When the triangular flap included between these incisions is doubled upon itself, the column and septum of the nose are perfectly formed. By an upward duplication of the lateral parts of the flap, the alæ and nostrils are next formed, and maintained by transfixing sutures. To facilitate the closure of the frontal wound and to obtain larger nostrils, Langenbeck does not remove the small triangular portions seen on each side of the base of the flap, but makes the central portion, from which the septum is made, rectangular and one inch wide. When the nose has thus been formed and the raw surfaces thoroughly cleansed, the new organ is brought into position and retaining sutures are applied. The most important sutures are those which hold the alæ of the nose to the cheek and the septum to the upper lid. For each wing and the septum three sutures are requisite; for the wings one externally, one internally toward the nostril, and one beneath toward the lip. Since it is the septum that most frequently fails to unite with the upper lip, unless extraordinary care be taken, it is advisable to make a special groove in the central part of the upper lip, three to five lines in length, into which the lower end of the septum is firmly implanted after it has been divested of cuticle. The operation is then completed by suturing the lateral margins of the new nose to those of the cheek, particular care being given to securing a good apposition of the pedicle in the upper end of the defect. If the wound in the forehead is very large, it may in part be closed by sutures, although the greatest caution must be observed to prevent traction on the pedicle. If the entire wound of the forehead is left to granulate no harm results, and the scar is probably not more ungainly than that which follows what is ordinarily an unsuccessful attempt at obtaining its closure by primary

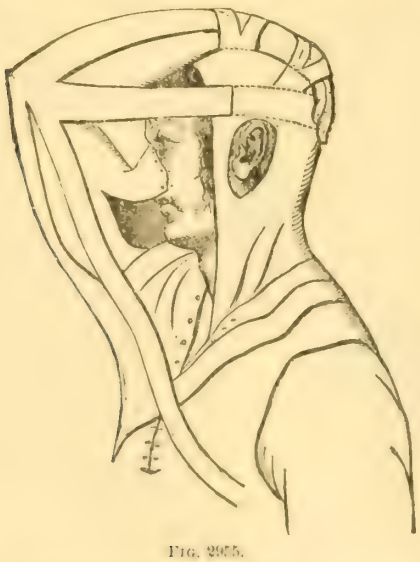


Fig. 2955.

union. To maintain the patency of the nostrils, and at the same time further adhesion of the double integumentary folds, it is well to introduce portions of a drainage-tube into the nostrils after the operation is complete. The new nose may then be lightly covered with oiled silk and antiseptic gauze or lint, care being taken that no foreign material becomes adherent to the sutures.

There are rare cases in which previous disease has unfitted the integument of the forehead or of the cheek for rhinoplastic purposes. Under such circumstances only is one justified in resorting to the Italian operation of rhinoplasty from the arm. The first step in this procedure is to outline a flap of integument from the inner surface of the middle of the arm, measuring four inches in length and three in width. The flap is raised between two parallel longitudinal incisions, but retained above and below in relation with the remaining integument. To prevent reunion a piece of oiled lint is placed underneath the flap. The inflammatory process which follows the elevation of the flap causes this to greatly increase in thickness, while its inferior surface,

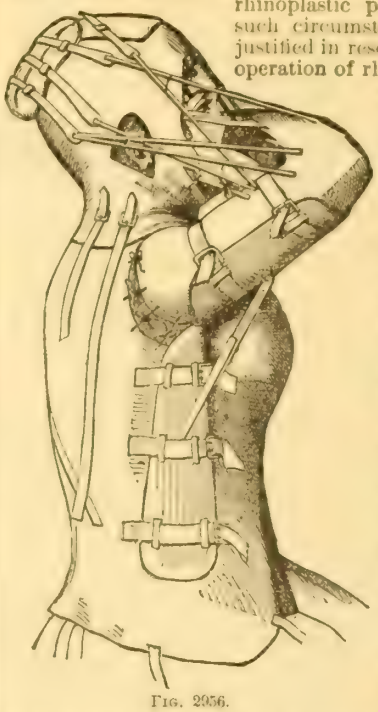


Fig. 2956.

in from two to three weeks, becomes clothed with granulations and eventually cicatrized. When, after the lapse of this time, the flap is sufficiently thickened, its upper connection with the arm is severed by a transverse incision which leaves a wide raw margin at the upper end of the flap, which is sutured to the vivified margins of the nasal defect. This part of the operation Tagliacozzi usually performed in the fourth week after the first operation. Since it requires from one to two weeks before the lower end of the flap can be safely severed from the arm, the latter must be supported in relation with the head and face. Fig. 2955 shows Tagliacozzi's method of accomplishing fixation of the arm by means of a cap and jacket. Wutzer's apparatus for obtaining a similar end is shown in Fig. 2956. In taking the skin from the forearm or back of the wrist, he found it necessary to support the arm and forearm in splints. When such an apparatus has been worn from one to three weeks, the upper end of the flap will have become firmly united to the apex and sides of the triangular nasal defect, and it is then safe to sever its brachial connections, when the formation of the wings and septum can be completed as in the Indian method. Graefe modified the Taliacotian operation by at once fixing the flap to the vivified edges of the defect, thereby apparently curtailing the period of fixation of the arm. This, which is known as the German method, has found even fewer followers in recent times than the older operations. It manifestly gives greater opportunity of shrinkage of the flap and subjects the patient to the annoyance of a large suppurating surface near the mouth, which by the older operation is cicatrized before it is transplanted. Dieffenbach exceeded both Tagliacozzi and Graefe in the extent to which he reformed the nose from a brachial flap, in that the entire nose, with the exception of one ala, was formed as the first step of the operation. After shrinkage and cicatrization had followed, the actual transplantation of the nose was effected in from six to eight weeks.

The operations thus far described, unless gangrene supervene in the flap, effectually close the nasal defect.

Plastic Surgery.

For the most part, however, the newly formed nose, irrespective of its original prominence, sinks and contracts until eventually little more than an integumentary curtain closes the defect. To obviate this result a number of procedures have been adopted, among which that of

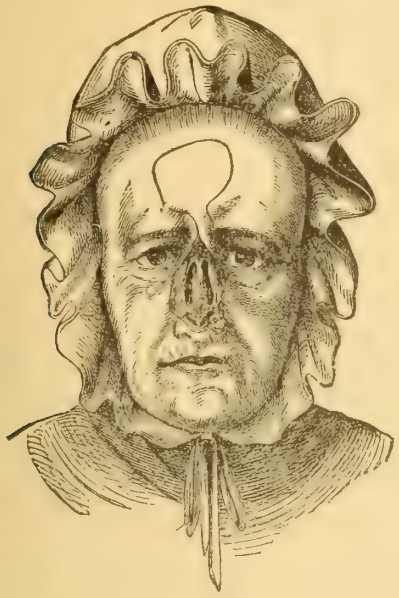


Fig. 2957.

Thiersch probably deserves most prominent mention. As the first step of the operation, he forms on each side of the defect a rhomboid flap from the cheek, the attached base of which is in relation with the freshened edge of the defect, its free border being external. When these flaps are raised from the cheek on each side they are inverted, so that the cutaneous surfaces look toward the nares, the raw surfaces outward, and in the median line

Fig. 2958.

are in contact with each other. The nostrils and septum being thus formed, a frontal flap is brought down to cover the flaps from the cheeks, the operation being completed in the ordinary way. Verneuil procured a permanent elevation of the bridge of the nose by a somewhat similar operation of superposition of the flaps. In this case the frontal flap was taken from the median line, and deflected in such a manner that the cutaneous surface looked backward. Over the raw surface two quad-

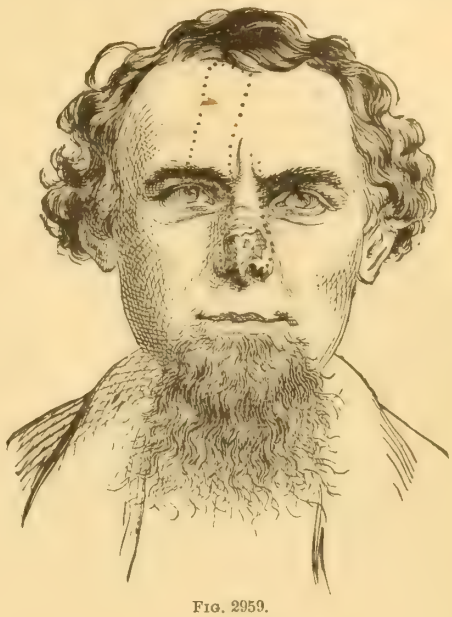


Fig. 2959.

rilateral flaps from the cheeks were brought by a process of gliding, and united along the median line. Finally, Langenbeck and Ollier have given the new nose an osseous substructure by sawing a strip one-fourth of an inch wide from the nasal processes on each side. This strip, after being broken through its attachments below, is deflected toward the median line, where it meets its fellow of the opposite side. If the nasal bones are present

Fig. 2960.

and only depressed, which they generally are, they must be brought into position by the free use of the elevator.

Quite recently König (*Langenb. Arch.*, vol. xxxiv., p. 165) presented to the Congress of German Surgeons a

method of obtaining an osseous framework for the repair of sunken noses, and for the permanent elevation of the nose after total rhinoplasty. The method is virtually one of superimposed flaps, both being taken from the forehead. A median flap of the requisite length and half an inch in width is formed from the forehead in the

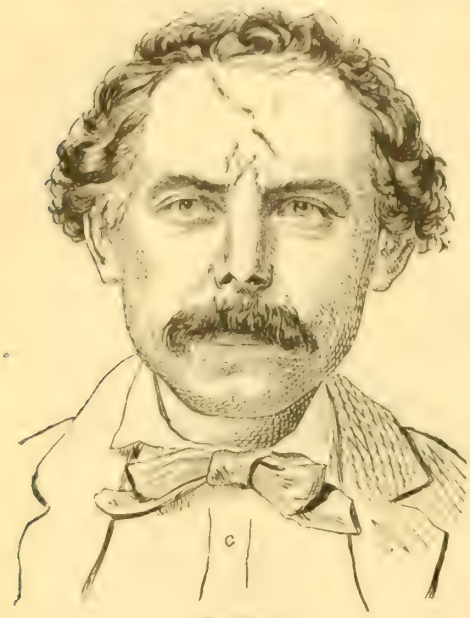


Fig. 2961.

median line. The incisions bounding this narrow strip are carried down to the bone. When this flap is raised the external table of the frontal bone is raised with it as far as the root of the nose. The flap thus elevated is inverted, so that the cutaneous surface faces the nasal fossæ. Over the raw external surface a second frontal flap is then placed and fixed as in the ordinary Indian

Fig. 2962.

operation. In four cases in which König performed this operation for a sunken condition of the nose, the repaired organ retained its solidity after from one to nearly four years had elapsed from the time of the operation.

The partial destruction of the nose also presents many interesting peculiarities that require partial rhinoplasty. When the tip and ala of the nose are intact, while the body and bridge are lost, the defect should be closed by a frontal flap (Figs. 2957 and 2958). In this case Linhart removed an epithelioma involving almost all the cartilages and a portion of the bony framework of the nose—only the margin of the nostrils on each side was preserved. Mutilations of the tip of the nose can also be repaired by a frontal flap. Figs. 2959, 2960, and 2961 illustrate the defect and the results of operation in a case of Buck's, in which the tip of the nose was bitten away. In this case the freshening of the edges of the defect was followed by the elevation of the patch of skin above the defect as far as the root of the nose between the eyebrows. A frontal flap of requisite length and width was then brought into the breach, the skin previously displaced from the nose being placed into the frontal wound. In Fig. 2960, *a* and *b* indicate the disfiguring prominences resulting from rotation of the flaps. When these were excised the admirable result shown in Fig. 2961 was obtained.

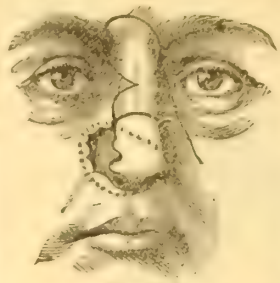


Fig. 2959.

Fig. 2964.

The tip of the nose may also be repaired with a flap from the cheek (Linhart) (Fig. 2962). The pedicle of this flap extends quite to the root of the nose; its broad end may be divided by two incisions (dotted lines for forming parts of the nostrils and septum, as in total rhinoplasty. Before the flap can be inserted, the remaining integument of the nose must be divided in the median line and reflected on each side. It frequently happens that with the tip one of the nasal ala and the columna are lost. To repair this defect the integument of the root of the nose, of the glabella, and of the internal angle of the orbit was utilized by Busch (Fig. 2963). The pedicle of the flap is placed on the healthy side of the nose, low down, and on a level with the defect. When the flap is brought into position, its lower portion forms the tip and columna of the nose, while its upper part, when duplicated, replaces the lost ala. The repair of defects of the nasal wings can be accomplished by a number of procedures. When the defect is long but narrow, it is probably best, as Dieffenbach taught, to refrain from attempting a plastic operation, and to produce a similar defect on the opposite wing. In some cases it is advisable to excise the defect in a triangular way, and to close the breach with a flap from the side of the nose. Fig. 2964 illustrates the method of obtaining it and the incisions (dotted lines) necessary for placing it in position. In larger defects of a nasal wing it is advisable to procure a flap, quadrilateral in shape, from the cheek or from the upper lip. In Figs. 2965 and 2966 the method of Bonnet is shown; to give the angle of the nose a more shapely form, and to facilitate the rotation of the flap, a wedge-shaped portion (*b*) may be excised from the base of the flap. In this operation the vermilion border of the flap must be removed, and the fissure in the lip is to be closed at once. Perforations of the

Fig. 2965.

Fig. 2966.

nose resulting from wounds or ulcerative processes are generally seated at the side of the nose. They may readily be closed by flaps of suitable shape and size, taken from the forehead, from the cheek, or from the opposite side of the nose.

The nasal column, when it alone is defective, can be admirably repaired from the central portion of the upper lip, which must be included between parallel perpendicular incisions. When the flap thus formed is brought in contact with the nasal septum, its mucous surface is of course exposed, and is eventually converted into skin.

In the most complicated of nasal defects, finally, other parts of the face are, as a rule, deficient. This is particularly true of the upper lip, of portions of the palate, and of the cheek. In such complicated cases, as has already been intimated, many operations are required before the face can be made at all presentable. In cases of this character the lip, the angle of the mouth, and the nose all require separate operative treatment. If, however, from one to three years be devoted to the judicious management of such a case, the result will in every way repay patient and operator for the patience displayed.

Joseph Ransohoff.

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[2] Celsus: Lib. vii., cap. ix. [3] Buck: Repar. Surg., p. 11. 1876.
[4] Denucé: Arch. Gen., 1855, t. vi., p. 402
[5] Szymanowsky: Oper. on the Surface of the Body. Kiew. 1865. In Russian only. [6] König: Lehrb. der Chir., Bd. i.
[7] Arch. f. klin Chir., vol. xxiii., p. 323. [8] Chir. Réparatrice, p. 116.
[9] O. Weber: Pitha and Billroth, Bd. iii., i., p. 148.
[10] Arch. f. klin. Chir., i., p. 95.
[11] Ollier: Compt. Rend., 1861, 53, p. 84.
[12] Arch. f. klin. Chir., 5, p. 33. [13] Gaz. hebd., i., p. 416.
[14] Chir. Répar., p. 118, 1854. Verneuil, p. 311.

PLEURISY. Inflammation of the pleura is one of the most common of diseases, and occurs in both sexes and in all climates; although it is less common in young children than in adolescents and adults, it is encountered even in infants and in its so-called primary form, though it is then often overlooked. The frequency of the disease can be inferred from the rarity with which, in examinations after death from any cause, the lungs are found entirely free from adhesions, the indisputable evidence of previous inflammation. This very frequency of the disease, as well as the great variety of conditions which it may complicate, follow, or cause, makes it somewhat difficult of satisfactory classification. It has been divided into acute and chronic, into general and local, into primary and secondary; it has again been classified with reference to the character of the inflammatory products. In this article it is proposed to employ a mixed classification—into primary and secondary with reference to etiology, with certain reservations which will appear below; chiefly according to the nature of the products, with reference to the other aspects of the disease. Pleurisy is generally unilateral, and when double is apt to be part of a general infection of some kind.

Etiology.—The existence and frequent occurrence of a primary pleurisy due to exposure to cold was, until of late years, universally held, and is still maintained by most American and English writers. There must, however, be some factor other than simple exposure—something in the individual—or every person, as well as the same person at different times, would be similarly affected by similar exposures; this remark has, of course, just as much and no more force with reference to pleurisy as it has with reference to any other affection attributed to this cause.

In Germany and France writers have come forward, and with the development of the germ theory are increasing in number, who maintain that pleurisy *à frigore*, so called, is as rare as it was formerly considered common—that pleurisy is in the great majority of cases tubercular from the start, the earliest distinct manifestation of a latent and local tuberculosis of the lungs or of the bronchial glands. The precise manner of the extension of the infection is not explained. This view seems to be based mainly on the indisputable fact that, while recovery from pleurisy with effusion is often absolute and permanent, cases are by no means rare in which, a variable length of time after apparent recovery, unmistakable pulmonary tuberculosis makes its appearance. Further and careful observation is needed to show which of these two views more nearly approaches the truth. There are, again, many cases of pleurisy classed as primary, which arise without any definite exposure to cold, and for which no satisfactory cause can at present be assigned, except by the advocates of the tubercular theory.

It is customary to class the traumatic pleurisies as primary, although, strictly speaking, they are secondary to the wound or injury of which they are the direct result. Thus, penetrating wounds of the chest are nearly always, fractured ribs and contusions of the chest-wall, often followed by inflammation of the pleura, which may be only local, but may also spread over a large part or the whole of the affected side.

Secondary pleurisy occurs under an immense variety of conditions, of which we can enumerate only the more important. Inflammation or disease in contiguous parts or organs—the chest-wall, the lung, the pericardium, the vertebral column—is liable to extend to the pleura: every acute pneumonia which reaches the periphery of the lung is complicated with more or less pleurisy; the pains in the chest suffered by phthisical patients are due chiefly to pleurisy. Thoracic aneurism, mediastinal tumors, and œsophageal disease may provoke the affection; which is also met with in some cases of peritonitis, apparently by transmission through the lymph-passages of the diaphragm. In the course of acute processes, especially the exanthemata and rheumatism; in pyæmia and septicæmia; in Bright's disease, especially the parenchymatous form; in gout; in heart disease resulting in dropsy, pleurisy is often set up. The hydrothorax of kidney disease is more apt to excite pleural inflammation than that of heart disease—the serum being more irritating, probably from the larger proportion of excrementitious matter in the former case.

Anatomical Changes.—The changes which take place in an inflamed pleura are essentially the same as in the other serous membranes. The earliest stages of inflammation are indicated by capillary congestion and small extravasations of blood into the subserous tissue and into the pleura itself; the membrane then loses its smooth, glossy surface, becoming rough, dull, and opaque, and is covered by a delicate gray deposit, consisting of fibrin, epithelium, and young cells; as the deposit increases in thickness, it becomes yellowish in color. This layer is sometimes smooth and sometimes presents a reticulated appearance. The above changes are usually more marked on the parietal than on the pulmonary pleura. In the rare cases in which a more or less general pleuritis stops here, and is not followed by liquid effusion, the inflammatory products are either absorbed entirely, the pleura recovering its normal appearance, or the opposing surfaces become adherent in whole or in part by organized connective tissue, and the sac is obliterated over the adherent areas. This result is much more liable to occur over the upper portions of the lungs, where the respiratory movements are at a minimum; over the lower portion the adhesions are stretched and torn apart by the alternate expansion and retraction of the chest, and often take the form of bands which more or less intimately and firmly unite the pleural layers. Complete obliteration over the bases is seen chiefly in severe and long-standing cases after absorption or evacuation of the fluid, especially in empyema and cases complicated by extensive chronic destruction of the lungs—phthisis. Simple adhesive pleurisy is in the great majority of cases local, and secondary to inflammatory processes in the immediate neighborhood of the part affected.

The next step to congestion and fibrinous exudation is the effusion of fluid, which is generally at first serous or sero-fibrinous, though it may contain so much blood as to be termed hæmorrhagic, or not infrequently later becomes purulent. It will be more convenient to treat of these three kinds of effusion separately.

Serous and sero-fibrinous effusions vary greatly in amount, from an ounce to a gallon or more; the fluid is sometimes perfectly clear, sometimes more or less turbid

from the presence of lymph-cells, nuclei, and coagula of fibrin, which float in the liquid or, with the other more solid constituents, gravitate to the dependent portion of the chest, especially after the body has remained in one position for some little time. The thoracic contents may thus be clear and thin above, but thick below. The reaction is alkaline, as a rule, and the effusion contains urea, uric acid, albumen, and cholesterin (Naunyn); even in the most serous effusions the microscope reveals the presence of a few red blood-disks and lymphoid cells. As the fluid increases in quantity the lung retracts before it, floating on its surface, and is not really compressed until its inherent elasticity has ceased to operate. If not bound down by old adhesions, the lung is driven upward, backward, and inward toward its root and the vertebral column; where, in cases of large effusion, it is found a flattened, airless, and bloodless mass which sinks in water, but can, for a variable length of time, be reinflated. If absorption takes place, the thicker and soluble constituents of the fluid are taken up first and more rapidly than the solid and cellular portions, which must previously undergo fatty degeneration. Sometimes the latter remain in considerable quantity and give place to connective-tissue growth, which starts from the surface of the pleura, denuded of its epithelium; such false membranes may be half an inch in thickness, grow tougher with age, and often contain cartilaginous plates and cretified deposits. In these cases it may be necessary literally to cut the lungs out of the body at the post-mortem. Occasionally, portions of the serous effusion are incapsulated by adhesions and remain unabsorbed for months, or even years.

An effusion is characterized as *hæmorrhagic* only when the presence of blood is unmistakable to the naked eye; the blood seems to be derived partly from the rupture of the newly formed and delicate adhesions, partly from diapedesis through the walls of the vessels. In view of the constancy with which we find ecchymosis in the recently inflamed pleura, the wonder is that so little blood gets into effusions generally. Hæmorrhage is always suggestive of tubercle, cancer, or sarcoma; but also may occur in connection with purpura or scurvy, and in bleeders. A chronic pleurisy is very apt to be the starting-point of tuberculosis, the miliary nodules lying in the pleura itself and in the fresh adhesions; each nodule is sometimes covered with a little shield of fibrin. In other cases, tuberculosis of the pleura is secondary to that process in the lung. Rare cases of hæmorrhagic effusion occur, in which none of the above causes seems to be operative, and in which recovery takes place.

It is not yet definitely settled whether *purulent* effusions ever have that character from the start. Very early in the course of the disease a clear and thin serous fluid may be converted into pus, or the transformation may be long delayed, infection coming either through the lung or from careless operative interference. In septic cases, and in gangrene of the lung, it seems probable that a thin and ichorous pus may be thrown out at the commencement; and the proneness of childhood to purulent effusion is notorious. The source of the pus is at first the blood-vessels, but the cells afterward proliferate, sometimes with enormous rapidity; the reaction is generally acid. These effusions are far more difficult of absorption—indeed, in adults, spontaneous absorption is one of the rarest of events—and after a time are apt to corrode the tissues, as if in the attempt to make their way outward. Thus a way may be opened through the pulmonary pleura, either by direct perforation into a bronchus or by superficial necrosis laying bare the lung-tissue. In the former case air is likely to escape into the pleural cavity, unless the opening be a valvular one; in the latter, as was pointed out by Traube, the pus passes through the lung as through a sponge, but air does not pass outward. Again, the pus may make its way through the costal pleura and point under the skin, like any other abscess; the most common seat of this occurrence is the upper front of the chest, in the second or third interspace, near the sternal border, where there is only one layer of intercostal muscles—[illegible]. During this process one or more ribs may become carious. In rare cases the pus may penetrate the abdominal cavity, follow the course of the psoas muscle, or perforate the pericardium, the œsophagus, and the like; it would lead us too far to enumerate all the courses which pus has been known to take in these cases. Occasionally, portions of the pus are incapsulated, and may either remain for long periods as multilocular pleurisy or empyema, or undergo cheesy metamorphosis.

The *secondary effects* of pleural effusion depend rather on the quantity than on the quality of the fluid. Retraction and compression of the lung have already been described, but it remains to touch upon the changes in other parts and organs. The more rapid the effusion the more hyperæmic is the lung of the sound side, which is compelled to aerate the blood that should be taken care of by its fellow; the increased functional activity is apt to produce more or less vicarious emphysema. Sudden death was formerly not a very rare event in cases of large effusion, but is now, fortunately, much less common—thanks to the general use of the aspirator. The fatal result is at times due to collateral œdema of the sound lung, at times to myocarditis, at times apparently to embarrassment of the heart, dependent on its dislocation, and at times to twisting and obstruction of the thin-walled vena cava at the point where it traverses the diaphragm (Bartels); it is especially in left pleurisies that the latter event is to to be feared. The above causes of death are chiefly operative early in the course of the disease; but if they are escaped, and the large effusion is allowed to remain, the slowing of the circulation may give rise to thrombosis in the right auricle or appendage, whence a portion of the coagulum may be swept into and obstruct the pulmonary artery or one of its larger branches in the healthy lung. In proportion to the amount of the fluid the mediastinum and heart are pushed toward the opposite side and the diaphragm is forced downward; dilatation of the affected side of the chest is to be looked for only in comparatively young persons, whose costal cartilages are not ossified. In long-standing cases, in which the lung fails to re-expand in whole or in part, though the fluid disappears, the affected side of the chest falls in, the shoulder droops, the vertebral column curves laterally, the diaphragm ascends, and the vessels in the false membrane may become ectatic. The last-named change is especially marked in those enormously thick false membranes which occur in cases of chronic fibroid induration of the lung with bronchiectasis.

Symptoms.—In but few maladies do the symptoms vary so widely in different cases; they may be very characteristic, indefinite, or completely absent. Cases of acute primary pleurisy, such as are attributed to exposure, are apt to be best marked. The patient is feverish, suffers from chilly sensations for some days perhaps—a distinct rigor is rare—and complains of a sharp, stabbing pain, generally on the lower and anterior portion of the affected side, which leads him instinctively to suppress all motion of that side as far as may be; the pain is increased by external pressure, and is derived from the rubbing together of the inflamed pleural surfaces, though it is probably not altogether devoid of a neuralgic element affecting the intercostal nerves. The pain generally diminishes greatly or disappears as fluid is thrown out and separates the parietal from the visceral pleura. As the effusion is absorbed and contact is re-established the pain is apt to return, though with less intensity. Cough is rarely entirely absent, and in the early stages is short and suppressed by reason of the pain which it excites; it is either perfectly dry or accompanied by more or less scanty mucous or muco-purulent expectoration, due probably to slight bronchial catarrh. Profuse or bloody expectoration points to the existence of something more than pleurisy. The respiration is quickened, as it always is in diseases attended by fever, and is superficial, the patient often speaking in broken sentences. The more rapid the effusion, other things being equal, the earlier does serious dyspnœa or orthopnœa develop, and the greater is its degree—in well-nourished persons owing largely to engorgement of the lungs. As the fever falls

the dyspnœa may diminish greatly, although the effusion is quite stationary. In cases of large and rapid effusion the difficulty of breathing is generally most distressing and threatens life; but large quantities of fluid, causing marked dislocation of organs, may occasion comparatively little dyspnœa, provided the formation has been gradual enough to allow the circulation to adapt itself to the changed condition. The fever ranges at the beginning of the attack from 100°–104° F. (37.8°–40° C.), and follows no typical course; it generally shows slight morning remissions and defervescence is gradual, coming on after from one to four weeks—a crisis such as is often seen in pneumonia is one of the rarest of events, if, indeed, it ever occurs. Jobbé-Duval thinks the temperature of the affected is always higher than that of the sound side, but this point is not as yet definitely settled. The pulse is always accelerated, and at first hard and small from increased arterial tension, which, however, subsides as the effusion is thrown out freely. The writer has noticed marked irregularity of the pulse in some cases during the declining stages, and has questioned whether this symptom may not be due to a slight extension of the inflammation to the pericardium. If there be much dislocation of the heart, irregularity is a grave symptom. In the earlier stages the patient generally lies upon the healthy side, any pressure increasing his pain; but as the effusion increases he turns upon the affected side or sits upright; he then affords better play to the sound lung and, in sitting up, can summon to his aid the accessory muscles of respiration. Cyanosis is marked only in severe cases in which the pulmonary circulation is seriously impeded, by reason either of very rapid or of very great effusion, weakness of the heart, or some important complication. In a certain number of cases, and these are generally the more vigorous patients, the appearance is very suggestive; but in others it presents nothing really characteristic. As in most other acute diseases attended by fever, the appetite is impaired, the tongue is apt to be coated, and the bowels are somewhat confined. The urine during the increasing and pyrexial stage is scanty, high-colored, and of high specific gravity, with often a trace of albumen and a few casts; it is a fever-urine, but something more, as the great diminution in quantity, in common with the low arterial tension, depends mainly upon the obstruction to the pulmonary circulation. The right ventricle is unable to force the usual amount of blood round the lesser circuit, and the left ventricle consequently receives and can supply less to the arterial system; the proof of this explanation is furnished by the increase in arterial tension and in the bulk of urine which follows re-expansion of the lung after tapping. The quantity of water passed in the twenty-four hours may be reduced to a few ounces.

In cases which run a favorable course the symptoms abate with the subsidence of the fever and the absorption of the fluid. The appetite and digestive power return, the urine increases—sometimes very greatly—in amount, but the pain in the side may return in a measure as the pleural surfaces again come in contact. In some cases the patient is perfectly conscious of the pleuritic rub, not as a pain, but as a peculiar catching or dragging sensation, felt especially toward the end of inspiration. Entire recovery may be speedy in slight cases, but it is generally very gradual, and it may be many months before the patient regains the same power of physical exertion which he had before his attack. The physical signs are even slower to clear up, and the base of the chest may tell the story of the inflammation throughout the remainder of life. Sometimes, again, recovery makes some progress, but is interrupted by a fresh inflammatory attack and perhaps renewed effusion—relapsing pleurisy; this may even be repeated several times, constituting a very tedious form of illness, the recovery from which is long delayed, and is apt to be only partial; such cases awaken serious anxiety as to the development of tuberculosis at that or a later period.

When pleurisy is limited to, or especially befalls, that portion of the membrane which invests the inferior surface of the lung, it is called *diaphragmatic*, and may give rise to peculiar and strongly marked symptoms. The breathing is carried on, as much as possible, by the upper portions of the chest, and is excessively rapid; the patient sits up, is very anxious, and fearful of any motion; the pain shoots up to the shoulder and round to the back; hiccough, if present, heightens the distress. The symptoms, in short, are very alarming; but the physical examination is negative, or nearly so—the pulse is good, there is no fluid effusion, and the feeble respiration over the base is not necessarily indicative of anything more than shallow respiration. Similar symptoms may be presented by local inflammation of the peritoneum in the neighborhood of the diaphragm. A friction rub or other evidence of pleurisy detected elsewhere in the chest will of course facilitate the diagnosis. Recovery generally takes place, and well-marked cases are fortunately not common.

Hæmorrhagic effusion presents no peculiar symptoms, and those of purulent effusion are not, as a rule, distinctive. Cutaneous œdema of the affected side of the chest points to pus, which is also to be suspected in scrofulous and broken-down individuals, children, and the colored race. In advanced phthisis very often, and in septic cases almost invariably, the fluid is purulent. Severe and prolonged constitutional disturbance, with sweating, marked loss of weight and strength, and hectic fever, are also indicative of pus. But suspicions are, by puncture, so readily converted into certainty that the symptoms of purulent transformation are less important than they were before that procedure was introduced to general use.

A very rapid and rare form of pleurisy in previously healthy persons is described by some writers as coming on with severe chills, very high temperature, cerebral disturbance, and other typhoidal symptoms. Pus forms rapidly in the chest, and puncture affords only the most passing relief, death occurring from suffocation or exhaustion within ten days or a fortnight from the onset of the disease. Fraentzel has seen only three cases of this sort, and it still remains to be ascertained whether a free incision under antiseptic precaution, as soon as the diagnosis is established, may not modify their course. As was stated previously, a purulent effusion rarely shows any tendency to absorption. In empyema necessitatis the opening is generally so high that the cavity is not properly drained, and nature very seldom effects a cure. Discharge of the pus by rupture into a bronchus is not infrequently followed by recovery; the earlier in the course of the disease such rupture occurs the more extensive is pneumothorax likely to be.

Many cases of pleurisy are nearly or wholly unattended by symptoms, and are discovered only by physical examination during life, or after death on the post-mortem table. This is very often the case with dry or adhesive pleurisy, which in cases of phthisis is apt to be a distinctly conservative process, closing the general pleural sac against the rupture of a pulmonary cavity. The frequency with which old adhesions are found at autopsies, irrespective of the cause of death, has been already remarked upon. Secondary pleurisy, as a concomitant of severe infectious disease, is also, as a rule, perfectly latent as far as symptoms are concerned, and is overlooked unless the chest is carefully examined. Again, patients not infrequently seek advice because for some time they have not felt up to the mark, or find that their breath is somewhat short on exertion, and the signs of effusion are found in the chest. Sometimes the fluid is in large amount and has produced well-marked dislocation of neighboring organs, particularly the heart; it may even be purulent. In these cases the onset was marked by no constitutional disturbance which attracted the attention of the patient, and the accumulation was so gradual that the system could adapt itself to the changed condition. Such patients sometimes work up to the time of presenting themselves for advice. The physician notices that the respiratory movements are quickened, and may see a slight play of the alæ nasi even when the patient is at rest. Cases of latent pleurisy with large effusion are not unknown among the well-to-do classes, but are

more common in hospital out patient rooms, for the reason that those who are in comfortable circumstances are, as a rule, more observant of themselves and invoke medical aid earlier.

Physical Signs.—(*a*) *Local, Dry, Adhesive Pleurisy.*—If there is pain, inspection shows the superficial quickened respiration and the restrained movement of the affected side; the suppressed character of the cough is also noticeable. There may be marked local tenderness. In the absence of pain the physical signs are limited to the friction-rub, heard on auscultation, and sometimes distinctly to be felt by the hand or finger-tips laid upon the part. Dulness on percussion is rarely sufficient to afford any conclusions of value. The signs of the first stage of acute and more or less general pleural inflammation are the same in kind as those of the local variety; the difference is rather one of degree, depending on the area affected and the fact that pain is more constant and more severe. Although the adventitious sounds produced in fibrinous pleurisy are often very distinctive in character, they may so closely simulate râles produced near the surface of the lung as to render it difficult to distinguish between them. The typical friction-sound is heard in both respiratory acts; is superficial, seeming to arise near the ear; is jerky; can often be intensified by pressure with the stethoscope, if the absence of local tenderness warrants the practice of this test; and may be described as dry, creaking, or grating. In local pleurisy it can be heard, of course, over a very limited area; in the first stage of general acute pleurisy the lateral region of the chest is that in which it is most apt to be found. Its absence does not permit the positive exclusion of pleural inflammation.

(*b*) *Pleurisy with Effusion.*—Whatever the character of the fluid, the physical signs are essentially the same. They vary, however, within very wide limits, according to the amount of the fluid; this fact must be constantly remembered, as, in the description that immediately follows, completeness will not be aimed at so much as such a presentment of general principles as are applicable to all grades of effusion, and a thorough comprehension of which is necessary to an understanding of the matters in question. He who has a clear idea of the changed physical conditions involved in pleural effusion will seldom have much difficulty in interpreting the physical signs present in any particular case. It must be premised that small quantities of fluid cannot be detected with certainty. Amounts less than eight to ten ounces (200–300 c.c.) seldom give rise to distinctive signs.

Inspection.—If the patient is in the recumbent position he is apt to lie on the affected side, thus affording better play to the sound lung. In the erect position or in dorsal decubitus the limitation of movement of the affected side is more or less marked in proportion to the amount of the accumulation. As the effusion increases, the pain due to the contact of the inflamed surfaces disappears, and with it the shallow, rapid respiration, with suppressed cough, so often characteristic of the first stage. In large effusions the contrast between the free excursion of the sound side and the absence of movement on the affected one is very striking. The latter at the same time appears larger, and the intercostal spaces, instead of lying below the level of the ribs as in the normal condition, are more nearly or quite flush with them. Bulging of the intercostal spaces above the level of the ribs is more rare than the writings of many authorities would lead us to suppose. The eye should also note the seat and distribution of the cardiac pulsations. In left-sided effusion the heart beat may be seen a variable distance to the right of the normal position, at the right or left sternal border, or even outside of the right nipple; or, if the apex lies under the sternum, the beat may be conspicuous by its absence. Other things being equal, the thinner the chest wall and the wider the intercostal spaces, the more evident will be the cardiac movements. The displacement of the heart to the left is never so great in right effusion as it is to the right in left effusion, rarely reaching much farther than the anterior axillary line in the former case. In large effusions on the right side inspection may show fulness below the margin of the right ribs, due to the downward displacement of the liver. In rare cases more or less extensive pulsation of the affected side has been observed, similar to that which occurs in aneurism. In these cases the fluid is nearly always purulent and in the left chest.

Palpation.—If there is notable effusion no friction-fremitus is to be felt, and tenderness is not apt to be marked. Voice-fremitus is diminished or lost over the fluid, through which the vibrations are not easily transmitted. The cardiac movements may often be felt, though they may be more appreciable to sight than to touch. The lower edge of the liver may, in the case of large right effusions, often be felt, as low, sometimes, as the anterior superior spine of the ilium. Œdema of the chest-wall points also to pus. Fluctuation is very rare.

Measuration shows the size of the affected as compared with the sound side, and the amount of excursion of the sides on forced respiration. The cyrtometer shows the relative shape as well as the relative size of the two halves of the chest.

Percussion yields information of the utmost importance for diagnosis. Dulness appears first over the lower and posterior portions of the chest, and is not noticeable in front until a considerable accumulation has taken place. Dulness gives place to flatness as the fluid increases in amount and the lung-tissue is farther and farther removed from the chest-walls. Thus the upper portions of the affected side may be dull while the base is perfectly flat. A sense of increased resistance under the finger is in a direct ratio to the loss of resonance. Above the level of the fluid the pulmonary resonance, besides being somewhat dull, may have also a tympanitic quality, due, as is supposed, to the relaxation of the lung-tissue, which, under these circumstances, is capable of being thrown into regular and musical vibrations. In moderate effusions, uncomplicated by adhesions or inflammation of the lungs, the line of flatness in the back—the patient being in the vertical position—is lowest near the spinal column, and lies in a curve like the letter *S* as it passes outward toward the axillary region. The experiments of Garland with reference to this point are well known. Before attempting to mark out this line the patient should be told to take several deep inspirations, in order to inflate the triangular portion of lung which dips down near the vertebræ. Damoiseau noted, many years ago, that the line is not straight; the explanation is to be sought in the fact that the fluid is moulded by the lung until the elasticity of the organ is exhausted instead of uniformly compressing the lung from the start, as was formerly generally supposed. The lower border of the effusion cannot be differentiated from the upper surface of the liver on the right, but percussion aids in determining the position of the lower edge of that organ. In large left effusions, with descent of the diaphragm, there is a diminution or loss of resonance in the area over the left lower costal cartilages—the semilunar space of Traube—beneath which the stomach and a portion of the spleen lie in the normal condition of the parts. The displacement of the mediastinum toward the sound side, and the cardiac area can also be mapped out by percussion. With very large effusions flatness may extend up to the clavicle, or, again, we may hear in the first or second interspace a tympanitic note which changes in pitch when the mouth is opened; this is called the tracheal tone of Williams, and depends on the transmission of vibrations from the primary bronchus. A cracked-pot sound can sometimes be elicited in the same situation.

When the chest is only partially full of fluid, and adhesions do not interfere with the free movement of the latter, some change in the level of the dulness and flatness can often be made out on change of position of the patient; under these circumstances the fluid of course tends to occupy the dependent portions of the chest.

Over the sound lung the vesicular resonance is apt to be exaggerated, and to extend lower than usual in the back, side, and front.

During the declining stage of the effusion the line of flatness descends as absorption progresses, but more or

less dulness is apt to persist for a long time over the lower portions of the chest, even after the fluid has disappeared. The degree of this dulness varies with the degree of expansion of the lung and the thickness of the false membranes or of the fibrinous deposit which is left behind. The dulness may gradually disappear, sometimes only after the lapse of a year or two, or it may remain in a measure for life.

Auscultation.—For precisely the same reason that a diminution and loss of resonance on percussion are encountered in pleural effusion, the respiratory murmur is enfeebled or absent in typical cases over those portions of the chest occupied by the fluid. The vesicular quality of the murmur is preserved in beginning effusions, the intensity being greater above than below the level of the fluid. As the lung begins to be compressed a bronchial element appears, and becomes more and more marked as the compression increases, the cartilages of the larger bronchi keeping them patent. Thus in large effusions the respiratory murmur is either absent, except near the site of the compressed lung, or, if heard, is bronchial in quality. Different cases vary much in the distinctness with, and area over, which bronchial respiration is to be heard, and this variation is one which is not at present easy of satisfactory explanation. Certain it is that a murmur of surprising intensity can often be heard over places which we know to be far removed from the lung; while in other cases, apparently similar in every way, there is in such locality a complete absence of breath-sounds. The important practical lesson to be drawn from this fact is, that the presence of loud bronchial respiration over the side of the chest does not serve to throw out large pleural accumulation. In still other cases the quality may be bronchial, but the intensity slight and the murmur apparently of distant origin.

Deep inspiration may in slight effusion be accompanied by fine râles, closely simulating the crepitant, which are produced by dilatation of collapsed portions of the lung. Friction-sounds may in slight and moderate effusions be heard just above the level of the fluid. Coarse, dry, or moist râles indicate an affection of the lungs or of the bronchial tubes.

From a careful study of the voice-sounds in pleuritic effusion, indications of great value may be obtained; their changes are more constant and, consequently, more trustworthy than those of the respiratory murmur. The vocal fremitus is diminished or lost over the fluid in proportion to the amount of the latter; bands connecting the two pleural surfaces may, however, carry the vibrations to the portions of the chest-wall overlying them with undue distinctness. Over the lung above the level of the fluid in moderate, and near the root of the lung in large effusions, bronchophony is often heard. Less importance is attached to-day to the peculiar nasal and tremulous character of the voice, called ægophony, than was formerly the case. It was thought by Laënnec to be characteristic of pleurisy with effusion, but is also encountered at times over cavities and solidified lung. Baccelli thinks that the transmission of the whispered voice indicates a serous, its loss a purulent, effusion; but general clinical experience does not bear out the truth of his observation.

Over the sound lung the respiratory murmur is harsh and of increased intensity—puerile respiration.

No lengthy description of the auscultatory phenomena of the stage of absorption is necessary. As the lung re-expands there is a gradual return toward the normal respiration, which may, however, remain feeble for a long time, or permanently, if complete dilatation of the lung is slow or fails to take place. Pleural friction is more common and more extensive during the third than in the first or second stages. Over thickened false membranes the vocal fremitus is apt to be increased.

The Complications of pleurisy are neither very frequent nor numerous. Pleurisy is more apt to complicate pneumonia than is pneumonia to complicate pleurisy. Pericarditis occurs not infrequently in connection with left pleurisy, through extension of the inflammation from one serous sac to the other. Peritonitis is sometimes secondary, but chiefly in septic cases. Acute nephritis is a rare complication. So also is the extension of the pleural inflammation to the connective tissue of the lung, with the development of interstitial pneumonia, so called. Sudden death, pneumothorax, and the spontaneous evacuation of purulent effusions outward and inward have been touched upon under the head of pathological anatomy. The pathological doctrines of the present day are against the conversion of pleurisy into tuberculosis. The former is either a complication or a manifestation of the latter, which had already gained a foothold in the system; or else, by impairing the functional activity and the circulation in the lung of the affected side, it acts as a predisposing cause, preparing the soil for the reception and growth of the tubercle-bacilli.

The distortion of the chest which follows gradual absorption of the fluid, the lung at the same time failing proportionally to re-expand, has been alluded to. In chronic empyema there is danger of amyloid disease. The occasional occurrence of cerebral abscess in connection with empyema must also be mentioned.

The *course* of the disease varies very much in different cases, according as it is general or local, primary or secondary, attended with much or little effusion; another and very important cause of variation in this respect is the character of the effusion; so also the duration of the disease before treatment is begun, and the wisdom with which the latter is carried out. In general, the duration of simple pleurisy with effusion, running a fairly favorable course, is at least four to six weeks.

The Diagnosis is to be based chiefly on the physical signs, the symptoms being suggestive rather than distinctive. Pleurisy in the first stage is liable to be confounded with pleurodynia and intercostal neuralgia, both of which cause pain in the side, with unilateral limitation of the respiratory movements; in neither of these is friction to be heard, but the cases of true pleurisy in which it is absent are not infrequent. Before physical examination was added to our means of diagnosis these affections were doubtless often confounded. Even to-day it may be impossible to make a positive diagnosis on the first visit. Even if a friction-sound is heard we cannot always be sure that the pleurisy is not that which accompanies an acute pneumonia reaching the periphery of the lung. The crepitant râle and rusty expectoration are characteristic if present, but may be absent; here, again, a position of reserve is often necessary for a day or two.

After effusion has taken place the diagnosis can be reached more promptly and certainly. In acute cases pneumonia is the only disease which is likely to give rise to confusion; in chronic cases the possible existence of thoracic or abdominal tumors encroaching on the thoracic space must also be taken into consideration. The physical signs of pleural effusion have been already fully described, and it will be sufficient here to summarize very briefly. A lung consolidated by pneumonia lies against the chest-wall, while in effusion the lung is separated from the wall over a greater or less extent and by a variable thickness of fluid. A loss of resonance on percussion is common to both, but can attain a higher degree in pleurisy, in which the distribution of the dulness may be characteristic. The breath-sounds and, above all, the vocal fremitus, however, are strongly contrasted in the two affections—in pneumonia we look for an intense bronchial respiration and a greatly increased vocal fremitus; over an effusion we expect to find the murmur absent or feebly bronchial, while the fremitus of the voice is diminished or lost. Signs similar to these latter may be obtained over a pneumonic portion of lung, provided that the main bronchus belonging to it is plugged. The plug will oftentimes be dislodged by coughing, all doubt then disappearing. Change of level in the dulness coinciding with change in the position of the patient is characteristic of pleurisy, and dislocation of other organs occurs practically only in pleurisy or pneumothorax, which are readily differentiated by percussion. The possibility of a combination of effusion and pulmonary consolidation must be borne in mind. In cases which still remain doubtful after other tests have been applied, an exploratory puncture, readily practised with a hypoder-

nic syringe, can be made. A negative result does not absolutely exclude effusion, for reasons which are sufficiently obvious, but which will be considered under the head of Operative Treatment.

Chronic pleurisy may be confounded with tumors arising from the lung, from the pleura itself, or in the abdominal cavity. Echinococcus cysts which have not suppurated are characterized by a fluid free from albumen; the hooklets may also be recognized under the microscope. The disease is very rare in this country, but a case was recently in the Boston City Hospital, which was supposed to be one of empyema until a free incision gave vent to the cysts in large numbers. The parent cyst started from the superior portion of the liver, and encroached on the thoracic space as far as the second rib.

Encapsulated pleurisy may give rise to great difficulties of diagnosis, which can be removed only by puncture, perhaps repeated several times. Pulsating empyema may simulate aneurism; the writer has seen a pulsating abscess arising from a carious rib.

The chief points on which reliance is to be placed in determining the nature of the fluid have been already mentioned in another place. When there is the least doubt it may be removed by puncture.

Prognosis.—Dry pleurisy in itself involves no dangers, and is often a conservative process. Whatever views one may hold as to the frequency of primary pleurisy with effusion as an independent disease, it cannot be denied that recovery, absolute and permanent, is common enough. Relative recovery is also common, more or less of the evidences of previous pleural inflammation being obtainable on physical exploration, but the patient enjoying good health and attaining length of days nevertheless. Still, in view of the fact that tuberculosis does develop in cases of this latter class, after an interval which may be long, we cannot regard them with quite the same equanimity as we are justified in preserving in cases where rational and physical signs alike disappear entirely. In general, it may be stated that the prognosis is governed more by the nature of the effusion, the age of the patient, his peculiarities of constitution, inherited or acquired, the circumstances in which he is placed, and his enjoyment of early and judicious treatment, than on the amount of the effusion. A large effusion may run a comparatively rapid and thoroughly favorable course, while a moderate effusion may be very tedious and be followed by very serious consequences. A purulent effusion in a child, treated properly and betimes, is apt to do well; quite as well as a sero-fibrinous effusion under similar circumstances in an adult. Empyema in a grown person is more unfavorable than in a child; but in non-septic cases, and in those free from demonstrable pulmonary complications, it proves very manageable as a rule. Ichorous and hæmorrhagic effusions are of evil import by reason of the conditions which underlie them. The danger of sudden death in large effusions, and by auricular thrombosis and its consequences in large and long-standing effusions, or with a feeble heart, has been already touched upon.

Treatment.—*Local adhesive pleurisies* are always secondary, and, apart from the pain or discomfort which they may cause, demand no special treatment; it is the underlying disease or condition which must receive chief attention. The dry cup is a favorite remedy with the writer; marked relief often follows the application, which any attendant can easily be taught how to make. Mild counter-irritation also renders good service in many cases. It is sometimes good treatment to strap the affected side of the chest, or to fix the whole chest with a broad swathe, thus limiting the movement which gives rise to the pain. In general, it is better to procure comfort by some such means as those above indicated, if possible. If they fail, if the pain is very severe at the start, or if there is much harassing cough, morphia is indicated, and should be given in such doses and repeated at such intervals as is seen to be necessary. The less, however, that is needed the better, as the drug is so apt to impair appetite and digestion.

Acute pleurisy in the first stage affords two indications for treatment—first, the limitation of the extent and progress of the inflammation as far as is possible; second, relief to the pain which it causes. The first indication is to be met mainly by rest in bed, and by an unstimulating, chiefly liquid, diet. Venesection in this disease has gone entirely out of vogue, and with good reason. It is very questionable whether bloodletting in any form limits in the least the amount or the course of the inflammation in simple uncomplicated acute pleurisy; however this may be, it is in a high degree probable that any good effect which may follow the procedure is attainable by the local abstraction of blood by means of leeches or wet cups. These measures are very rarely used at the present day; perhaps too rarely. They may be curative, and are generally palliative, diminishing the pain, and thus promoting the comfort of the patient. The other palliative means of treatment are, in the main, those which were enumerated under the head of dry pleurisy—mild counter-irritation, or strapping, and morphia, which is generally required.

During the second stage, and while fever still continues unabated, the treatment is also chiefly symptomatic. After appreciable effusion has taken place the pain is apt to diminish or disappear, and as long as there is active inflammation, as indicated by the temperature-chart, there is seldom much use in attempting to promote the elimination of the effusion. If perfect rest in bed and a suitable diet are maintained, and the proper action of the bowels is insured, many cases run a perfectly favorable course, absorption of the effusion taking place more or less rapidly, and complete recovery following in time. There are, however, cases in which active interference is desirable—nay, is imperative—whether fever be present or not, and quite apart from the nature of the fluid. In moderate effusions which have come on so rapidly as to markedly embarrass the breathing, or to notably distress the patient; and also in large effusions, however comfortable the patient may be at the time he is seen by the physician, no time should be lost in diminishing the amount of the fluid; for which end the readiest and best means is puncture. Under these circumstances a sudden access of dyspnœa has many times proved fatal, and the probability that reaccumulation will take place is no contraindication to operation. No attempt should be made to empty the sac; the withdrawal of a moderate amount of fluid is followed by temporary relief, and the system has a better chance of accommodating itself to the changed intra-thoracic condition. As to the manner of puncture and the precautions to be observed, mention is deferred for the present.

The beginning of the third stage is marked by the cessation of an increase in the fluid, and by a downward tendency of the temperature. The indications in this stage are to promote the rapid and complete disappearance of the inflammatory products, and to restore the strength of the patient. Often in moderate, and sometimes in pretty large effusions, nature herself, almost or quite unaided by special medication, can accomplish the cure; at the same time the cases are rare, and mostly of very slight intensity, in which the cure cannot be hastened by judicious medication. In other cases nature requires more or less assistance; in others, again, she is indisposed to take the initiative, and must be vigorously urged. With the abatement and disappearance of the fever, rest becomes less imperative, and the patient may be gradually and cautiously allowed to sit up, to leave the bed, to move about his room, to get into the open air. The diet may at the same time be gradually augmented, and the appetite if deficient, may be promoted by bitter tonics, mineral acids, and the like. The indications for alcoholic stimulation are, in all stages of the disease, to be derived from the condition of the patient rather than from the name of the malady. In general, it may be stated that whatever tends to restore deficient heart-power, and to increase the general vigor, is directly of service in hastening absorption, shortening convalescence, and promoting recovery. Apart from these general and hygienic measures, if the absorption of the fluid is halting or delayed, there are various other means of stimulating the proc-

ess. Continuous and mild counterirritation of the skin over the lower portions of the affected side, by the repeated application of the tincture of iodine, is frequently practised, and seems to be of some service. A great limitation of the quantity of fluids ingested has been advocated by some, but is of rather doubtful efficacy, and the end in view can be attained in other ways less annoying to the patient. The internal administration of the iodide of potash is thought to promote absorption. There are three main avenues of elimination, which may be opened in turn, if need be—the skin, the kidneys, and the intestines. As diaphoretics, jaborandi, or pilocarpine, and the hot-air bath are chiefly to be recommended; as diuretics, digitalis, or one of the other drugs which comprise the digitalis group, combined with an alkali; as cathartics, elaterium, compound jalap powder, or Epsom salts. The latter can be given by Hay's method, so called, half an ounce to an ounce of the drug being given in concentrated aqueous solution early in the morning. The less fluid there is in the intestines at the time of absorption of the drug the more marked will be the hydragogue effect; the patient should consequently take but little fluid the night before. It is not, in the opinion of the writer, worth while to plague a patient by repeated purgings or sweatings, although if he shrinks from puncture there is no objection to giving them a fair trial; but, apart from prejudice, the discomfort of puncture is really less, and its results are more sure.

Convalescence from acute pleurisy with effusion should be carefully watched, and all those means should be employed which experience and common-sense show to be promotive of the general vigor. A patient should be kept under occasional observation until all traces of the disease have vanished. Active and gradually increased exercise, preferably in the open air, is very important, as encouraging complete expansion of the lung and absorption of any remaining inflammatory products. A walking-tour in the mountains is an admirable thing, when the season and the circumstances of the patient permit it. If, in spite of these means, the normal capacity of the lung of the affected side cannot be restored on account of the abundance and strength of the adhesions, the patient should regulate his future life with more reference to what the late Dr. George Derby, of Boston, happily called "hygienic righteousness" than might be necessary had he never suffered from the disease under consideration.

It is highly probable that pneumatic treatment will prove to be of real service in these cases, particularly those of them who cannot go to the mountains and there unconsciously practise pulmonary gymnastics.

Puncture.—It has been seen that the indications for this procedure are, irrespective of the stage of the disease or the presence of fever, notable dyspnœa and distress in moderate effusion, and large effusion whether these symptoms are present or not. The next indication is the failure of nature and of well-directed art to at least initiate absorption within a reasonable time, say three weeks at the most. The longer the lung is compressed, other things being equal, the less rapid and complete is re-expansion likely to be, and we cannot insist too strongly on the desirability of securing perfect recovery.

To Dr. Bowditch, of Boston, belongs the enviable credit of first applying suction to the evacuation of pleural effusions, and of demonstrating the absolute safety of the procedure with proper precautions. He tells me that he has operated over four hundred times on about two hundred and fifty patients without a single serious accident. The great opposition which at first greeted this and other useful innovations has not only disappeared, but at present every physician considers himself, and ought to be, competent to perform the operation.

The precautions are absolute cleanliness of the needle or trocar, which it is well also to pass through an alcohol flame immediately before introduction; certainty that the apparatus, whatever its pattern, works well; the avoidance of the admission of air to the chest; the slow withdrawal of the fluid, that the lung may have time to follow it down; and the cessation of the operation, and withdrawal of the instrument, as soon as the patient begins to experience the least distress. The physician who observes these will certainly spare himself anxiety and perhaps self-reproach; to say nothing of the interests of the patient, which are, however, really always identical with those of the physician. The cases of sudden death during aspiration which have been reported are attributable either to shock from the puncture or to the too rapid removal of the fluid, the lung failing to keep step. Alarming symptoms may follow a neglect to cease operating when the patient feels distress.

The choice of the apparatus the writer regards as of altogether subordinate importance, provided that the apparatus is clean and good of its kind. Any one of the various aspirators of the shops; a Davidson syringe, as advocated by the late Dr. Flint; or simple siphonage through a yard or so of rubber tubing, filled at first with an aseptic solution, and with its lower end kept immersed in the same during the operation, are all applicable. This latter method has the advantage of simplicity and is especially applicable to acute effusions, in which absorption is apt to go on rapidly after the removal of a portion of the fluid. Of course the basin containing the lower end of the tube must be below the level of the chest.

Another simple method is to fasten a condom securely around the end of the cannula or needle; the membrane when wet allows the fluid to pass outward with ease, but collapses at once with the slightest inward suction. Under circumstances of urgency it is better to operate at once, with such tools as are at hand, and to risk the admission of some air into the chest.

If the heart is weak it is well to give a little alcoholic stimulant before, and perhaps again during the operation, and to let the patient keep the recumbent position. Whenever it seems safe to do so, the writer prefers to operate while the patient is sitting up with proper support. Whether the puncture is made in the back below the inferior angle of the scapula, or in the side just in front of the edge of the latissimus dorsi muscle, is not a matter of great moment. It is not invariably an easy matter to distinguish between an intercostal space and a rib; but we should always endeavor to do so, and should keep the finger-tip on the point of election as a guide. A preliminary incision through the skin with a bistoury we regard as quite unnecessary. The needle should be inserted with a quick plunge; and if a rib is struck, the point must be raised or lowered until an interspace is reached. The free movement of the point of the instrument is one indication that a cavity has been reached.

Sometimes when we are perfectly certain that there is fluid in the chest there is no flow, either because a fibrinous clot occludes the end of the instrument or because false membranes have been pushed ahead of the point, which then does not lie in the cavity. If the flow cannot be established by suitable and safe manipulation, it is better to withdraw the needle and insert it in a fresh place. After two or three "dry taps" success may finally reward our efforts.

Whenever it is desired to terminate the operation the needle should be quickly withdrawn. It is customary then to put a bit of plaster over the point of puncture, but the real importance of this is doubtful. There is never any leakage if a moderately fine instrument has been used. It is rarely necessary to repeat puncture in acute cases, but there should be no hesitation in so doing if absorption is still delayed. It is safer to keep patients quiet for a day or two after the operation, but the writer has known hospital out-patients to be tapped and sent home soon afterward without obvious injury. The other after-treatment follows the same lines which have been sketched in connection with effusion which does not demand operative interference.

In *chronic* pleural effusion operation is always indicated, and it is frequently necessary to repeat it one or more times. The employment of a greater suction-force than can be obtained from simple siphonage is also oftener required. If, after several trials, the lung refuses to re-expand, and the effusion returns, it is not worth

while to persist. Cases are recorded in which a serous effusion has existed for years without becoming purulent or very seriously incommoding its owner. The open operation has been done a few times in these cases, but not as yet often enough to allow final conclusions. Success is hardly to be looked for from the open operation under these circumstances, unless a generous excision of portions of ribs is also done. A general tonic regimen and other measures calculated to favor gradual absorption are in place in chronic just as in acute pleurisy.

The general principles which should govern the management of encapsulated sero-tuberculous effusions are precisely similar, and need no minute discussion here.

Not so, however, with *purulent* effusions. It is true that occasionally, and especially in children, one or two tappings have effected a cure. But this is so rare that it may be laid down as a general rule that a purulent effusion demands free incision and efficient drainage just like any other abscess. When it is thus treated the results are often surprisingly favorable and rapid.

It is generally safe, and has usually been the practice of the writer, to give ether in these cases, and enough should be given to produce complete anæsthesia. The only serious accident which has come to the knowledge of the writer was death, apparently from syncope, in a case in which the etherization was not complete. It is far easier to adjust the drainage-tubes and the dressing with thoroughness and care when the operator is not hurried by a desire to inflict the minimum amount of pain.

In general purulent effusion the point of election is the side, just in front of the anterior edge of the latissimus dorsi muscle. The chest-wall is here thin, the opening is dependent in almost every position of the body, and the presence of the tubes interferes but little with the comfort of the patient. The lowest admissible point for the incision is the eighth interspace, and it is often better to select the seventh, or even the sixth.

It is almost unnecessary to insist upon the importance of the strictest cleanliness of all instruments and appliances.

A stiff director, sharpened at the point, can now be thrust into the chest, and the exit of pus along its groove shows that the cavity has been reached. The opening is then to be enlarged on the director as a guide, to the extent of at least an inch, and the pus is to be allowed to escape freely. There is, of course, no danger of its escaping too rapidly, as air enters the chest and thus equalizes the pressure. In a fair number of cases the pus is fetid, a peculiarity which is not ordinarily of evil import. After a few dressings the fetor is apt to disappear, and a recovery as prompt as complete may follow. There is some difference of opinion with regard to the advisability of washing out the chest in all cases. Sir Joseph Lister advises against the procedure, which is probably unnecessary if fetor and pus-clots are absent. When the latter are present an irrigation of the chest breaks them up and aids in their expulsion; if allowed to remain they act as irritants, keep up the discharge, and delay recovery. When irrigation is practised it is better to use the officinal solution of chlorinated soda, diluted with twelve to fifteen parts of water, than carbolic acid, very small quantities of which are sufficient to poison certain individuals. It is important to use the soda in the dilute solution above recommended, as stronger solutions cause coagula firm enough to give trouble. A fountain-syringe affords the best means for irrigation, allowing easy regulation of the pressure—a point of especial importance some days after the operation, when the delicate adhesions may easily be broken up by a forcible current.

After the thorough evacuation of the pus, two drainage-tubes, fastened side by side, should be introduced and fixed in place by safety-pins and plaster. Nothing is to be gained by allowing the tubes to project much beyond the skin or inner surface of the chest-wall. They are designed simply to facilitate the discharge from the cavity, and the irritation which their presence causes should be reduced to a minimum. If the ribs are so near together that tubes of a proper size cannot be introduced, or, after introduction by the aid of a dilator, are in any degree occluded by the pressure of the ribs, a portion of rib should be removed.

The application of the dressing is a very important matter, and worthy of description in some detail. A ring of loose gauze wrung out of an antiseptic solution is to be placed about the drainage-tubes, and over this a piece of mackintosh large enough to project in every direction beyond the gauze beneath it. This is covered by a dozen layers of dry gauze, and then by a sheet of cotton-batting, and the whole is held in place by a gauze or flannel bandage, some turns of which should pass over the shoulder. The real advantages of this dressing were first, as far as is known to the writer, pointed out by Dr A. T. Cabot, of Boston (*Boston M. & S. J.*, 1883, ii., p. 145). The prevention of sepsis was dwelt upon by Lister, but Cabot has shown that such a dressing as is described above has a very important valvular action, allowing the escape of air and fluid from the chest and, at the same time, obstructing the re-entry of air. Cough, sneezing, and forced respiration force the contents of the cavity outward; but as the chest contracts again in expiration, the elastic bandages and dressing compress the edges of the mackintosh overlapping the gauze about the tube against the chest-wall and thus maintain every gain in the expansion of the lung. It is very important to secure good expansion as early as possible after operation, that the adhesions, the formation of which constitutes part of the cure, may bind the lung down at or near its normal limit.

The dressing should be changed within twenty-four hours after operation, and then at such intervals as the amount of the discharge indicates. If the operation and the application of the drainage-tubes and dressings are done with careful attention to detail, the discharge rapidly diminishes in quantity and soon becomes serous in character.

One tube should be removed when the discharge is reduced to about a drachm in twenty-four hours, and the second when the discharge is no greater than would come from the track of the tube. A general tonic and hygienic treatment is to be followed up while the tube is in place, and also after its removal.

In cases in which a cavity persists from failure of the lung to expand, whether by reason of long compression and the formation of tough adhesions or other cause, portions of ribs should be resected, with the aim of allowing the chest-wall to fall in and thus bring about obliteration of the cavity, cessation of the discharge, and recovery. This procedure is often necessary in encapsulated purulent effusions, which are apt to be of long standing.

When a purulent effusion is merely a complication of pulmonary tuberculosis, it is, as a rule, not advisable to operate. The underlying lung disease is not favorably modified, and the comfort of the patient is not promoted by a thoracic fistula constantly discharging and requiring dressing.

It may be a matter of great difficulty to decide from the physical signs whether the lung itself is affected or not, but in the microscopic examination of the sputum for tubercular bacilli we now have at our disposal a diagnostic criterion of great value.

Frederick C. Shattuck.

PLEURISY ROOT (*Asclepias*, U. S. Ph.; Butterfly Weed). The root of *Asclepias tuberosa* Linn., order *Asclepiadaceæ*, one of the most beautiful plants of the genus. It is a hairy perennial, with upright or ascending, very leafy stems, simple below, but branching at the top enough to bear several umbels of showy, orange-colored flowers. The leaves are numerous, generally sessile, oblong, lanceolate, thickish, scattered or whorled, sometimes opposite. The flowers have the remarkable structure of the genus, made familiar in the common milkweed—the "crown," the pollen masses, and curious union of stigmas and anthers. Fruit of two follicles, hairy outside, not tuberculated, many seeded. This is a native of the United States—from New England southward and westward. The root, as found in the market,

is "large and fusiform, dried in longitudinal or transverse sections; from one to six inches (25 to 150 millimetres) long, and about three-fourths of an inch (2 centimetres) or more in thickness; the head knotty, and slightly but distinctly annulate, the remainder longitudinally wrinkled. Externally orange-brown, internally whitish, tough, and having an uneven fracture; bark thin and in distinct layers, the inner one whitish; wood yellowish, with large, white, medullary rays; it is inodorous, and has a bitterish, somewhat acrid taste; when long kept it acquires a gray color."

The composition has not been sufficiently studied. Whether it contains the "*asclepion*" of *A. Syriaca* Linn. is uncertain. Some bitter principle, possibly gallic acid, and the common vegetable substances have been demonstrated in it. A "Resinoid" is prepared from it by the eclectics. Although this drug has been before the profession for more than a century, and considerable use has been made of it, no very definite properties have ever been proved to belong to it. It is said to be diaphoretic and expectorant, and in domestic and country practice it has been used extensively in lung affections and catarrhs of the air-passages. In large doses it is cathartic. If desired, it can be given in decoction. Dose from one to three grams (gr. xv. ad xlv.).

Allied Plants.—The genus contains sixty species, mostly American. They generally exude a milky juice upon puncture which contains a little inelastic caoutchouc. The silky hairs of the seeds of one or two species have been spun as vegetable silk, but have but little strength or cohesion. The taste of most species is acrid and disagreeable; some are irritant gastric poisons. A few are cultivated for ornament. A number of plants of other genera in the order have a place in local materia medica, but none of them is really good. *Hemidesmus indicus* R. Brown, Indian Sarsaparilla, is considerably used in India as a substitute for Sarsaparilla. *Solenostemma Argel* is a griping gastric irritant, formerly found mixed with Alexandrian Senna. *Calotropus procera* R. Br., "Mudar," and *Tylophora Asthmatica* Wright and Arn., are also Indian remedies; both are emetics. (See also Cundurango.)

Allied Drugs.—The list of expectorants is a large and confusing one. It is doubtful if this root belongs among the expectorants, or is entitled to a careful comparison with them. For cathartics, see Rhubarb, Senna, etc. *W. P. Bolles.*

PLOMBIÈRES is situated in the northeastern part of France, lying in a well-protected valley, at an elevation of about fifteen hundred feet above the level of the sea. The climate is rather changeable, and there is often a considerable difference in the temperature between the day and night. There are in the neighborhood of thirty mineral springs at Plombières, the waters of which range in temperature from 66° to 158° F. They are very weak in mineral constituents, containing only about $\frac{1}{10}$ part per thousand of water. Very little use is made of the water internally, but it is employed chiefly in the form of baths and douches. The diseases for the relief of which a visit to Plombières is said to be indicated, are chiefly gout, rheumatism, digestive disorders, chronic diarrhœa, and diseases of the nervous system. The season extends from the first of June to the middle of October. *T. L. S.*

PNEUMOCOCCUS. Friedländer and Frobenius found in the lungs of persons dead from croupous (genuine) pneumonia a peculiarly-shaped micro-organism, to which they gave the name of pneumococcus. Later on, its presence was also demonstrated in the rusty-colored sputa of pneumonia, and in a specimen of blood obtained by cupping the back of a patient. Pneumococcus, strictly speaking, is a misnomer; its form is rather that of a bacillus, one diameter exceeding the other; hence "pneumo-bacterium," or bacillus of pneumonia, would be a more appropriate name. The parasite occurs singly, or in chains of three or four short, thick rods surrounded by a well-marked gelatinous capsule, which adapts itself to the form of the bacillus or to the chain of bacilli, looking more or less elongated. Generally only one bacterium is found in a capsule; whenever two or more are met with in a chain it may be assumed that the capsule failed to divide with the splitting of the bacterium. Spores have not been observed.

The pneumo-bacterium grows on gelatine and agar-agar, and luxuriates on potatoes. Test-tube puncture-cultures in gelatine show a white streak marking the puncture-canal, capped by a semi-globular, white, shining mass, the whole resembling an upholsterer's tack. Hence the name "nail-culture." This manner of growth is due to the fact that the pneumo-bacterium is anaërobe, as well as aërobe. Gas-bubbles sometimes appear along the puncture-canal. The gelatine does not become liquefied. When cultivated the parasite loses its capsule, presenting itself then in the shape of a naked bacillus.

Rabbits and guinea-pigs prove refractory to the virus, but when a pure culture is injected through the thorax into the lungs of mice, a process resembling croupous (genuine) pneumonia in man is set up. In this artificial lesion the capsulated pneumo-bacterium can be demonstrated.

Its occurrence in the rusty-colored sputa of pneumonia is comparatively rare, and in a number of cases it is entirely absent. This goes to show that it is of no diagnostic value. On the whole, it is very doubtful whether there is any causal relation between the presence of the parasite and pneumonia. Friedländer's methods of cultivation and inoculation are not free from serious objections. Besides, there are several micro-organisms which resemble the pneumo-bacterium, and which are found outside of any pulmonary lesions; neither its form (being enclosed in a capsule) nor the manner of growth of its colonies (nail-shape) is characteristic. The identity of the "bacillus of pneumonia," and its true relation to the disease in which it is found, will have to be established by future investigations.

Dilute aqueous solutions of gentian-violet or Bismarck-brown stain the bacillus in pneumonic sputa satisfactorily. The capsule can be plainly seen. Osmic acid (1 to 100) also brings out the capsule. Very dilute watery solution of eosine (twenty-four hours) gives good specimens. By Gram's method the bacillus is decolorized. For a description of the methods employed to make it visible in sections of lung-tissue, see vol. iv., p. 765.

The clinical course of pneumonia, and its occasional endemic and epidemic character, suggested its infectious nature long ago, but nothing definite is known about the habitat of the virus or the manner in which it enters the system. The experience of Emmerich, who found the bacteria in great numbers beneath the floor of a hospital ward in which cases of pneumonia had occurred, is, at present, still unique.

In the present state of our knowledge it may be safely asserted that there are probably a number of organisms capable of producing pneumonia. We know that aspergillus and actinomyces give rise to certain forms of it. A. Fränkel claims to have found the cause of genuine croupous pneumonia in a bacillus which much resembles that of Friedländer, and which he terms *bacillus septicus sputigenus*. This, too, is surrounded by a large, well-marked capsule. The *bacillus pneumonicus agilis* (Schow) and the *bacillus pseudo-pneumonicus* (Passet) may also be mentioned. They all resemble, but are not identical with, Friedländer's "pneumococcus." *L. Bremer.*

PNEUMONIA, IN CHILDREN. Synonyms.—Broncho-pneumonia, Catarrhal Pneumonia, Lobular Pneumonia, Capillary Bronchitis, Lung Fever, Inflammation of the Lungs, Suffocative Catarrh, Catarrhal Fever.

Broncho-pneumonia takes its name from the anatomical lesion, a lesion which is constant, and, as the name indicates, involves the bronchi (bronchitis) and the parenchyma of the lung (pneumonitis). It is preferred by recent writers to the name catarrhal pneumonia, since "catarrhal" is properly applied to lesions of mucous membranes, and, whereas it would be applicable to the lesions of the trachea and larger bronchi, it would not

apply with exactitude to the smaller bronchi, and not at all to the pulmonary parenchyma.

Capillary bronchitis, again, expresses only part of the lesion, for though, theoretically, the finer bronchi may become inflamed without the inflammation advancing to the alveoli, it cannot be doubted that this is exceptional, and practically is not met with.

To call it lobular pneumonia would be to give it a name based upon the distribution of the lesion, and since broncho-pneumonia may easily be extensive and involve the whole of a lobe, this name would give rise to confusion.

For these reasons the term broncho-pneumonia has been considered preferable. The remaining synonyms are nearly obsolete.

By broncho-pneumonia is meant that form of inflammation of the lungs most common in the extremes of life. It is occasionally met with in young adults, is frequent in old age, and is most common in infancy and childhood, up to five years of age. Acute general bronchitis and chronic bronchitis, and those diseases in the young naturally accompanied by bronchitis, have for a natural sequence parenchymatous pneumonitis. Its most frequent occurrence is as a sequel of measles, whooping-cough, scarlet fever, or diphtheria. It is clinically differentiated from lobar pneumonia by its relation to the catarrhal inflammation extending into the finer bronchi, by its gradual onset, its irregular fever curve, prolonged course, absence of crisis, and by its slow resolution.

In its pathological anatomy it is characterized by the infiltrated bronchi, the scattered and separate centres of inflammation, and by the fact that the alveolar contents are for the most part cellular.

Normal Anatomy of the Child's Lung.—The discussion of pneumonia in children may be much simplified by reflecting at the outset upon the peculiar anatomy of the child's lung.

The pneumonia of children is unlike that of adults in its clinical features and in its pathological anatomy, and the difference is due largely to anatomical diversity. This holds more strictly true up to the third year of life, and it usually stamps its characteristics upon the pathological anatomy of the secondary pneumonias up to the fifth year.

In examining the lung of a five-month fœtus it is found that the bronchi provide the most of its air-space. The bronchial tree has at the tips of its branches bud-like dilatations, rudimentary air-spaces. Between these dilatations, and separating them from each other and making up the remaining bulk of the lung, is loose, delicate connective tissue, so that air spaces and intervening connective tissue are about equal in extent. It is as though nature had laid out a bronchial tree of generous proportions at the outset, to meet the demands of new-born existence and to allow for its slower subsequent growth. On the other hand, the air-spaces, at the outset mere buds at the terminal tips of the bronchi, are destined to push their way into the delicate connective tissue, enlarge, subdivide, and finally, in early adult life, occupy all the available space among the branches, the loose connective tissue coming at last to be but thin, dense bands constituting the stroma. This serves to distribute the vascular network, and upon this are laid the close-fitting epithelial linings of the air-spaces.

In the five-month fœtus the air-spaces and connective-tissue interspaces are nearly equal in extent. During the first year of life, also, the alveolar walls are thick, and contain loosely their blood-vessels; and it is not until the fourth or fifth year that this development assumes the ripe proportion between alveoli and bronchi, and the stroma becomes dense and binding, restraining the capillaries as in adult life.

In fœtal life, again, the mucous membrane lining the bronchial tubes is loosely attached to the muscular walls. The mucous membrane is commonly seen lying in wavy folds within the contractile ring, where the same loose, delicate connective tissue is seen but loosely holding the growing tissues together. In infant life the underlying loose tissue gradually binds the mucous membrane to the fibro-muscular tube, and from this time it keeps pace in its growth with the other compact tissues, until, in adult life, it appears as dense fibrous bands.

As has been said, the aerating portion of the lungs develops as bud like dilatations at the tips of the smallest bronchi. These dilatations push their way into the stroma. The epithelium, departing from the columnar type of the smaller bronchi, covers the new-made walls with flat respiratory epithelium. From this primary expansion, to be known hereafter as air-passages, put off smaller branching buds, forming secondary divisions or alveoli with their infinite ramifications. At birth the space has been economized, and the loose connective-tissue stroma of the fœtal lung of five months has been condensed into rather thick alveolar walls. During the first two years the air-cells have not attained the proportion in capacity which exists in adults. The bronchial tree is still large in proportion to the dilating and multiplying alveoli. Again, the air-spaces developed from the terminal bronchi have covered themselves with a continuous layer of flat, nucleated epithelium. In its subsequent growth in adult life it is believed that the expanding alveolus does not increase its number of epithelia to cover the more extended wall, but somewhat enlarges their size, and, still further, some of the flattened epithelia lose their nuclei and expand to form large, very thin plates, called respiratory epithelium.

Another feature of the child's lungs, as contrasted with those of adults, is the behavior of the blood-vessels. Being loosely restrained in the walls, they easily become distended and tortuous, and encroach upon the cavity of the alveoli. With small alveoli, thick walls, and abundant distribution of vessels, it is easy to understand how, in hypostasis, distention of the vessels may be an important factor in displacing the air in feeble subjects with weakened respiratory vigor and partially obstructed bronchi. In short, the lung of the infant differs from that of the adult mainly in the following respects. Proportionately, the extent of bronchial tubes is greater than that of the air-spaces, *i.e.*, air-passages or air-spaces of the first order or division, and alveoli or air-cells of the second order or ultimate division. The connective-tissue stroma is likewise in greater abundance, and tends to cellular proliferation. The submucous connective tissue of the bronchi is loose and more abundantly supplied with nuclei, and its vessels are loosely held. The cells lining the air-spaces form a continuous layer. The alveoli are small, their epithelia proliferate abundantly, and the absorbents accomplish their work slowly, the blood-vessels playing a more important rôle. These facts are to be borne in mind in connection with the bronchial lesion which forms so important a part of broncho-pneumonia.

In studying the lesions of the child's lung, it is important to bear constantly in mind these anatomical peculiarities of bronchi and alveoli, blood-vessels and connective tissue. In considering tissues so little removed from the embryonal type, it must not be forgotten that embryonal cells tend to multiply rapidly, and thus appear abundantly in the products of inflammation.

Among the peculiarities of the child's lung may be mentioned the regularity with which the bronchial glands are swollen in inflammatory lesions, and the frequency with which they become tuberculous.

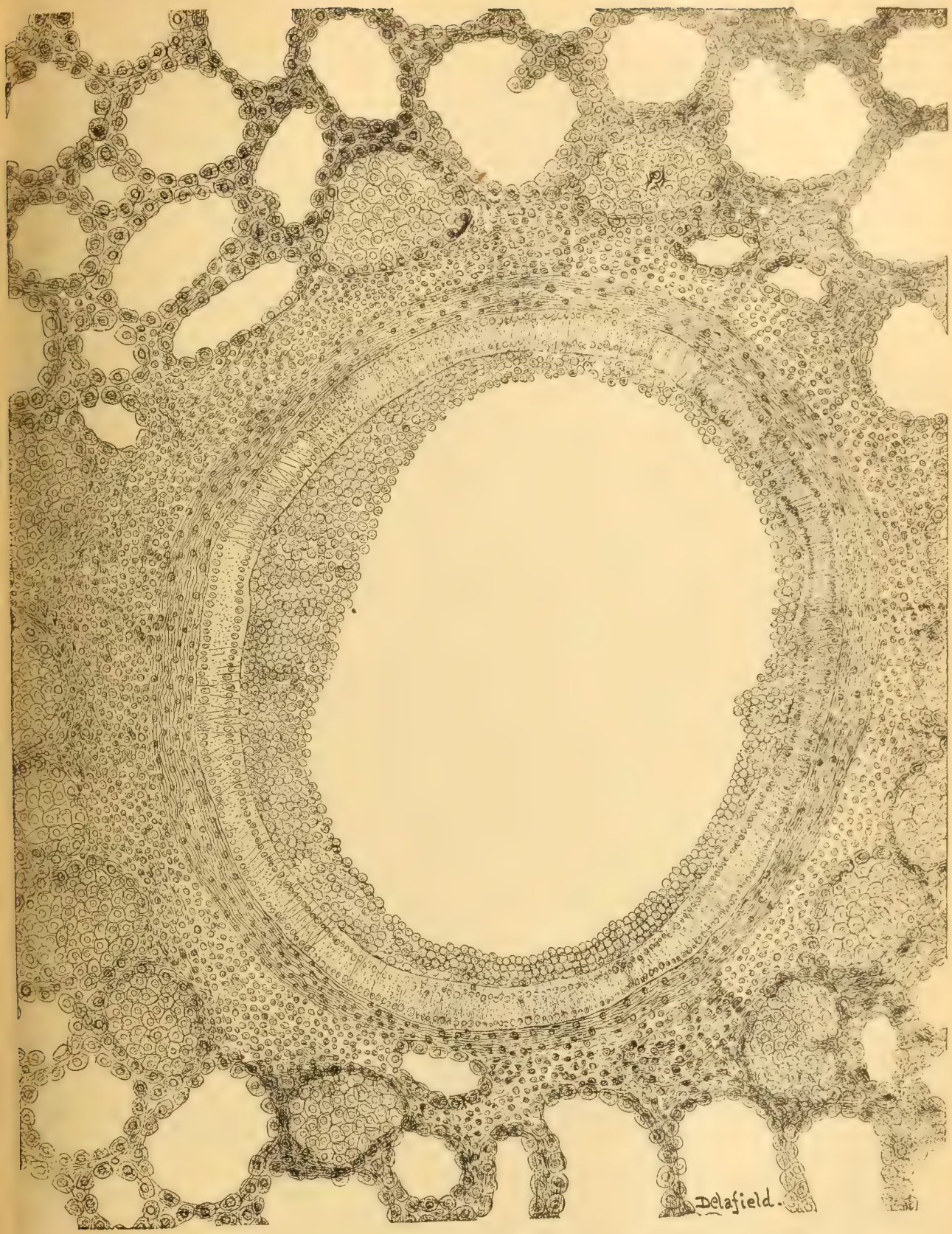
Anatomy, and the pathological changes and clinical observations of inflammations of the lung, unite in placing approximately the fifth year of life as the time at which the lung becomes adult.

Pathological Anatomy.—Pneumonitis has regularly associated with it bronchitis and tracheitis.

The common procedure is for the inflammation to advance from the larger to the smaller air-tubes, thence irregularly pushing its way into the finest, to the capillary bronchi, and communicating its inflammatory process to the terminal air-passages and alveoli.

In this process it may vary in the rapidity of its advancement, from an almost simultaneous attack upon the different elements, to a gradual invasion occupying several days or weeks.

It may advance more rapidly along certain bronchi, and so involve irregularly and successively different por-



ACUTE BRONCHO-PNEUMONIA.

(COPIED, BY PERMISSION, FROM DELAFIELD'S STUDIES IN PATHOLOGICAL ANATOMY.)

tions of different lobes of the lungs, or it may select certain extensive portions and thus simulate lobar pneumonia.

The bronchi may be severally involved with a few scattered lobules of pulmonary hepatization, with or without atelectasis, or larger scattered masses may be made up of adjacent lobules, or it may be diffused and lobar in form.

Whatever the extent of hepatization, whatever the time occupied in its course, whatever the post-mortem appearances, the essential lesion is bronchitis with pneumonitis—broncho-pneumonia.

To longer talk about "capillary bronchitis," or to give undue importance to pulmonary atelectasis, is to take a step backward, and by awkward terms to evince the confusion existing at the beginning of this century. Laënnec found current such terms as acute asthma, paralysis of the lung, suffocative catarrh, and he was the first to place the consideration of broncho-pneumonia on a correct scientific, pathological basis.

The pneumonia of children, whether running a short course and giving well-defined symptoms of consolidation or not, is anatomically broncho-pneumonia.

Whatever subdivisions made use of, whatever names applied, mark but arbitrary classification for convenience of description and reference.

The lungs are made up of bronchi, air-passages, alveoli, pulmonary pleuræ, and connective-tissue stroma, containing blood-vessels, lymphatics, and nerves.

In broncho-pneumonia all these elements may be involved.

Lesions of the Bronchi.—The lesions of broncho-pneumonia ordinarily include catarrhal inflammation of the trachea and bronchi. This process, though somewhat difficult to verify in its first steps, is believed to follow the analogy of inflammation of mucous membranes elsewhere, and to begin with congestion and swelling of the mucous membrane, with an arrest of function in the glands. The next step manifests itself by renewed activity, with an increase in the quantity and change in the quality of the products of the glands. An abundant, colorless, tenacious, viscid mucus accumulates. The congestion diminishes, the superficial swollen epithelium becomes detached, pus makes its appearance, and possibly a moderate amount of blood; a variable admixture of these elements causes the secretions to vary in consistence and color. Predominance of mucus gives a tenacious, stringy sputum which may exist throughout the bronchi. Coherent yellowish masses are due to excess of pus. If blood be present it still further modifies the color. Later the purulent sputum becomes thinner in consistence, still yellow and frothy. After death the mucous membrane of all the bronchi is usually reddened, and more or less swollen; it may, however, be pale and sodden, and coated with muco-pus. From the finest bronchi can be expressed creamy pus containing fine air-bubbles. In the finest bronchi, in addition, there is nearly always to be observed a most characteristic lesion, viz., the infiltration of the bronchial walls. In the loose connective tissue between the mucous membrane and the muscular ring already spoken of, small round cells appear early in the course of the inflammation. Small round cells infiltrate all the elements of the bronchial wall. These on section appear light gray, having the size and general appearance of miliary tubercles, for which they may be easily mistaken. They are, however, more uniformly distributed and have not the shining appearance of miliary tubercles usually found in the child's lung. On removing a thin, clean section parallel with the base of the lung affected with broncho-pneumonia, it is often possible to see distinctly outlined the infiltrated terminal branches within the lobules of the lung. A fortunate transverse section will often show the terminal infiltrated bronchi grouped in nicely fitting threes and fours, demonstrating the system of bronchial distribution. These rosettes of infiltrated terminal bronchi are best seen in the early stages of severe broncho-pneumonia following measles. They are transverse sections of the ultimate divisions of the bronchi within the lobule, congestion of the surrounding tissue serving to throw into relief the dull gray infiltrations.

In the literature, this condition of the bronchi has been given such awkward names as to lead to the belief that the minute condition is not fully understood. Let it be remembered that uniformly distributed grayish masses in a lung can mean but one thing, viz., infiltrated bronchi. In fact, the grayish appearance of a solid lung usually means pus.

Dilatation of the Bronchi. When broncho-pneumonia is acute and intense, and accompanied by abundant secretion, there is usually dilatation of the smaller bronchi. This is for the most part fusiform, involving many branches, and generally appears in the lower lobes of the two lungs. This condition appears most plainly in lungs carefully washed, or, still better, hardened in alcohol. Dilatation may be fusiform or saccular, the cavities often being a centimetre in diameter. Dilatation of the bronchi is associated with three conditions: (1) weakened bronchial walls; (2) abundant secretion within the bronchi; (3) impermeable tissue surrounding them.

Dilatation is due to the infiltration and weakening of the walls, and a consequent loss of contractility, the abundant secretion being forced by each inspiratory thrust, from larger to smaller bronchi, at the same time that air is not able to enter the surrounding partially collapsed portions. It is believed to be more common in very young children and in those enfeebled by preceding disease. It occurs most frequently after the fifth day of the disease, and in children between the ages of three and five years. These dilatations are mechanical, acute, and wholly disappear on the recovery of the patient.

We have then an ordinary catarrhal inflammation in the mucous membrane of the trachea, and of the larger and medium-sized bronchi. In the bronchi of the smallest size the character of the inflammation is different. Here the calibre of the bronchus becomes narrowed, the mucous glands are less frequent or wanting, the mucous membrane in its development has lost its characteristic columnar epithelium, and is in part replaced by flat respiratory epithelium similar to that in the air-passages and alveoli, and the membrane, partly mucous and partly respiratory, is found loosely attached to the walls by connective tissue of the embryonal type. The inflammation which above has expended itself superficially, here invades the deeper tissues. Small, round, nucleated cells known as embryonal cells, appear and tightly pack the loose tissue between the epithelial lining and the elastic bronchial wall. In addition there is congestion of the bronchial vessels, swelling of the epithelial lining takes place, and the lumen of the tube, thus narrowed and rigidly maintained, is filled with abundant pus.

Every portion of the wall is infiltrated, the connective tissue without the muscular layer being affected in a similar manner to that within (Plate XXVI.).

Lesions of the Parenchyma.—"Capillary bronchitis." By this term we mean an early stage of broncho-pneumonia, in which the lesions are yet mainly of the bronchi.

Capillary bronchitis is a misleading name, as has been maintained above. It is believed by the writer that inflammation of the finer bronchi virtually does not exist apart from parenchymatous changes. The term capillary bronchitis is, however, time-honored, and, having defined it, we will use it. It is here employed to designate the early stage of broncho-pneumonia, in which the lesion is mainly of the bronchi. There are ordinarily scattered lobules of consolidation, and the microscope reveals important parenchymatous changes. To class the lesion as a bronchitis would be misleading. It is here placed under broncho-pneumonia, among parenchymatous changes.

The finest bronchi are infiltrated and contain pus, as described above. In addition to this there is inflammation of the parenchymatous tissue of the organ, parenchymatous pneumonitis. Nothing can better illustrate this lesion than the recital of a rather unusual case of broncho-pneumonia following measles. The duration of the disease, so far as could be determined, was twenty hours. During the second day of the eruption the temperature suddenly and abruptly rose to 106° F., the fever

being accompanied by convulsion and severe dyspnœa. After death the pleuræ of both lungs were dry, lustreless and "sand-papered" over nearly the whole extent. There were no pellicles of fibrin, and no collection of serum in the cavities. On opening the thorax the size of the lungs did not diminish by escape of contained air. To the finger the sensation was uniformly doughy, and there was no consolidation. Along the posterior margin the consistence was slightly firmer, and the color purple.

On section the lung was found markedly œdematous, the posterior purple area was due to hypostatic congestion, and the larger bronchi contained tenacious muco-pus lying upon a reddened and swollen mucous membrane. From the smaller bronchi, when they were compressed, thick, creamy pus escaped. So far this gross lesion showed no consolidation. Uniformly distributed over the cut surface were to be seen small opaque, grayish bodies, rounded or stellate, about the size of a millet-seed. These were more marked and better seen in the lower lobe and posterior portion of the upper, especially in the area of hypostatic congestion, in contrast with the favorable background. On removing a thin section from the base, or a thin superficial section from the lateral surface, these small opaque bodies were seen in many places to group themselves into closely-fitting threes or twos, and to be encircled by a congested zone, and, at a little distance, by the lobular septum. The microscope demonstrated the opaque bodies to be infiltrated bronchi, and the appearance of grouping to be due to the fact that a transverse section of branching intra-lobular bronchioles had been made.

Further, as to the condition of pulmonary tissue, the alveoli contained proliferated epithelium, swollen and detached, and swollen and undetached epithelium and pus. The blood-vessels were engorged in the dependent portions.

This may pass for a typical example of so-called capillary bronchitis, and yet there was beginning extensive pleurisy over both lungs, and unmistakable beginning pneumonitis. The symptoms were those described as capillary bronchitis. The appearances on gross inspection of the lung might well have been characterized by the same name, but the microscope revealed very important changes in the parenchyma.

Atelectasis—Collapse—Fœtal State. These names indicate the different grades of a condition of lung frequently accompanying broncho-pneumonia. The conditions producing it are the presence of tenacious muco-pus in the bronchi and enfeebled respiratory power. A tenacious plug becomes wedged into a small bronchus. Each inspiration thrusts it farther into the narrowing tube. Expiration and coughing may displace it for the moment, but at the beginning of inspiration it again blocks the passage, so rolling back and forth in the manner of a ball-valve, excluding all further entrance of air. There soon comes a time when expiration has not the power to dislodge the plug, and the air beyond it remains imprisoned. Even yet coughing may force air past the plug, which again is forced back into the orifice, and the alveoli having parted with air and received none in return, have less atmospheric pressure within. The blood-vessels dilate, the walls partially collapse, the remaining air is absorbed, exudation of serum takes its place, and proliferated cells and leucocytes gradually restore the equilibrium.

Atelectasis is commonly symmetrical, affecting the posterior margin of both lower lobes, but it may be seen in irregular, scattered areas in the posterior portion of the upper lobes, and along the lower margin of the middle lobe of the right lung and the tongue-like process of the left. Its surface is smooth and shining, its extent definitely outlined by its violet color and sunken surface; on manipulation it is flabby, but moderately firm, not frangible. On section dark fluid blood escapes from the engorged vessels; the surface is smooth, with occasional lobules projecting above it and having a granular appearance. From the smallest bronchi can be pressed out creamy pus. Portions carefully removed are found devoid of air and sink in water. When examined under the microscope the following conditions are found: The bronchi are filled with pus and swollen and detached epithelium, the walls of the finest bronchi are infiltrated. The neighboring alveoli are partially collapsed, the remaining capacity being filled with swollen and proliferated epithelium and pus-cells, the blood-vessels dilated, tortuous, and gorged with blood, occupying more than their normal space. Here and there are found hepatized lobules.

The anatomical diagnosis is, then, broncho-pneumonia with associated atelectasis. The collapse is accessory.

The rôle played by collapse in pneumonia of children has been variously estimated, and the condition variously defined. In this article it is considered an accompaniment, and not a stage, of the process. It may be further added that the only satisfactory test of this condition is furnished by the microscope, although there is another which is confidently recommended and widely adopted, viz., passing air, under gentle pressure, into the affected portion, when the collapsed lobules become inflated while hepatized lobules remain unaffected.

The practice of inflating a lung at the autopsy-table by passing a pipe into the main bronchus and blowing gently upon it, is crude in the extreme, and has led to much confusion. I have never seen a case of atelectasis that would not yield to the gentle inflation, neither have I ever failed in atelectic areas to find abundant evidence of an inflammatory process, both in the capillary bronchi and air-passages and in the alveoli. In a lung removed from the thorax it is easy to see how air can be forced through the obstructing plug, and fill out the remaining capacity of the partially collapsed alveolus. This condition is common in the course of laryngeal diphtheria with suffocative symptoms. In such lungs it is often possible to restore the rose color by inflation, but this is deeper red than normal, and scattered along the posterior margin are impermeable hepatized lobules.

Carnification is a name well adapted to a form of pneumonia of slow development, found most often in enfeebled subjects. Carnified lung has a constant lesion, viz., inflamed and infiltrated bronchi. To this is added the important part played by the blood-vessels, together with partial collapse and the presence of the products of inflammation in the alveoli.

Its usual location is along the posterior portion of both lower lobes, though yet it is very common to find it involving the entire posterior margin of both lungs and the lingula. In many cases, when the child is allowed to rest much upon his back, it attains an uniform horizontal level in both lungs.

Enfeebled respiratory power, recumbent position, gravity, and hypostasis have long explained this condition. To this may be added another element. From the root of the lungs, after the division of the main bronchus, one of the largest branches passes to the lower lobe in a line nearly parallel to the posterior margin, giving off at frequent intervals branches to the dependent lung-tissue. Still another large branch passes from the root to the lower posterior portion of the upper lobe. It is apparent, from the study of a section with the subject lying on his back, that these two important bronchi are prepared to carry, by gravity, fluid contents from the trachea and main bronchi, for they are so situated as to catch the drain of the main respiratory tubes. The conditions, too, are favorable—dorsal decubitus, enfeebled respiratory power, partial or complete inactivity of the dependent portions of the lungs, gravity, and obstructed bronchi, working side by side with engorged vessels, hypostasis, collapse, and congestion.

Carnified lung contains in its alveoli and air-passages, and small bronchi well-marked evidences of pneumonitis as well as bronchitis. Its pleural surface is smooth and shining, depressed or level with the surrounding tissues, dark violet to dark mahogany in color, with occasionally punctate hæmorrhages, its consistence firm but flabby—like that of muscle. Its cut surface is of the same color, is smooth, not granular, uniformly level; dark fluid blood pours from the cut vessels, and creamy pus may be expressed from the bronchi; to the fingers

it feels spongy, is not easily torn, and is not frangible. On inflation, air may be made to enter slowly and irregularly, distending the remaining possible space in the lobules. Even then it does not return to the light rose-color of the anterior portions of the lobes.

Carnified lung has, in common with atelectasis, congested vessels, giving to it the dark violet-color. It, however, has within its air-spaces more abundant products of inflammation, giving it a firm, muscle-like feeling. The development is slow; its air-spaces contain in excess large swollen epithelia.

Hepatization.—Instead of the firm, flabby, muscle-like consistence of carnification, with the air-spaces partly filled with products of a slow inflammatory process, and the vessels laden with blood, we come now to a result of active proliferation. The lung is no longer flabby. Its surface is raised and firm. Its air-passages and alveoli are filled and distended with large and small cells and fibrin. Its connective tissue in bronchi and septa is infiltrated with serous fluid and small round cells. Its consistence is firm, frangible, liver-like. The pleura does not escape. It overlies an acute process in the lung-tissue. Over the hepatized tissue it takes on the behavior of serous membranes, and its smooth surface becomes covered with a fine pellicle of coagulated fibrin entangling pus-cells in its meshes. It should not be forgotten that bronchitis is an inseparable accompaniment of this hepatization.

It is very difficult to learn from post-mortem studies the rôle played by acute attacks of congestion. Active hyperæmia of a part may easily dissipate itself through the relaxed vessels after death, and leave little or no trace. By experiments it has been proved that injected capillaries, ramifying in the walls of the alveoli, can displace air from the lung to a considerable extent; and, contrariwise, that forcing air into the alveoli removes blood from the overdistended capillaries.

Hepatized lung, not overlaid with pleurisy, has a color of mahogany-brown, the tint varying somewhat with the contained blood, or marbled by the presence of pus. Its consistence is compact, firm, friable, easily broken down under the pressure of the fingers. The fibres of the stroma are everywhere parted and filled in with small spheroidal cells. On section the appearances are the same. The knife separates the liver-like substance with facility. The color is dark mahogany or marbled with gray; the tissue is scarcely moist, only a small amount of dark blood escaping from the open vessels. The surface is smooth or finely granular—not, however, so coarsely granular as in adults, where, in addition to cellular elements, there is a large amount of fibrin. The infiltrated bronchi are no longer outlined against the surrounding congested tissue, but are fused into the neighboring infiltration and held firmly in the consolidated mass.

These disseminated masses of hepatization are surrounded ordinarily by congested and œdematous spongy lung, in which can be seen infiltrated bronchi. In short, a commingling, side by side, of all the pneumonic processes can, not infrequently, be demonstrated.

For purposes of study it is convenient to divide broncho-pneumonia with hepatization into (1) Disseminated and (2) Lobar.

1. *Disseminated Broncho-pneumonia.* — The catarrhal inflammation of the trachea and bronchi may advance irregularly, and invade the capillary bronchi irregularly, lighting up inflammation in scattered lobules or groups of lobules. Here, again, gravity carries the secretions into the two main branches of the bronchial tree, which, according to the position of the child, lead to the lower lobes or to the posterior portions of both lower and upper. The most common location is in the lower lobes, irregularly distributed. Frequently, in addition, there is a small mass in the posterior portion of the upper lobe. It is, however, not unusual to find scattered masses of varying size elsewhere. A very common seat of isolated pneumonia, having somewhat different physical features, however, is the tongue-like process of the upper lobe of the left lung—the lingula.

Under atelectasis it has been said that the portions of lung of least mobility in respiration, such as the lingula, are the earliest to suffer when, in consequence of bronchitis, their inflation is imperfect. So, too, hepatization appears here frequently, having peculiar features. Its

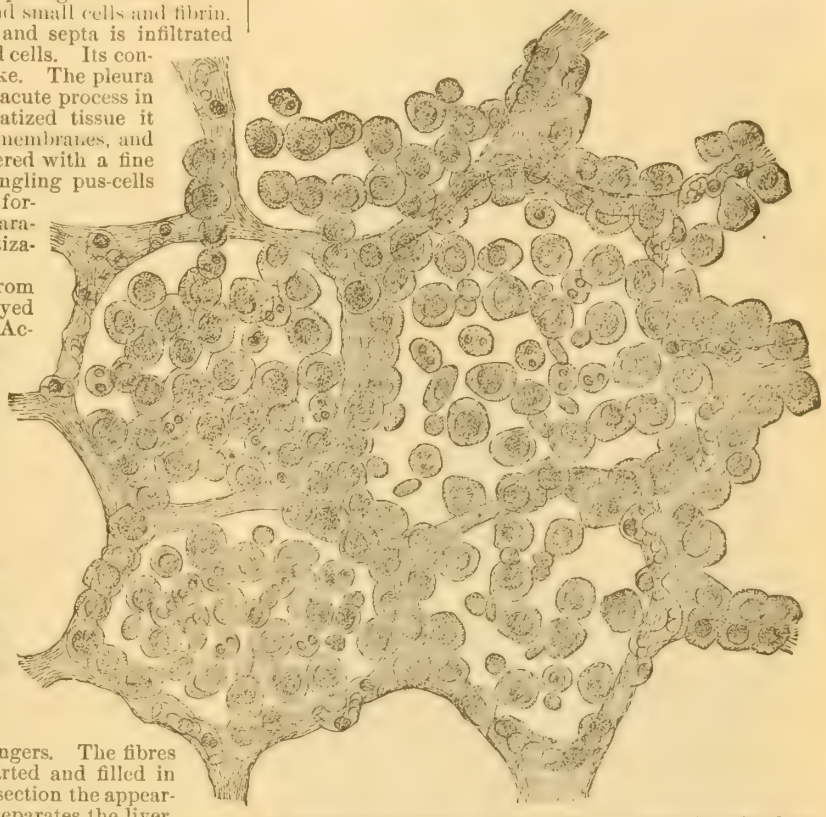


Fig. 2967.—Broncho-pneumonia in a Child, showing Air-vesicles in Diffuse Hepatization. (Delafield and Prudden.)

color is mahogany-brown; its surface is even with the surrounding tissue, but not smooth. It is nodular or mammillated. Its lobular divisions are distinct, often exaggerated, the nodules corresponding to the centres of the lobules. On section the lobules are seen equally distinct, and the septa broadened as though the lobule had shrunken, drawing apart the tissues of the septum. In the centre of the lobule a drop of pus oozes forth from the mouth of the cut bronchiole, and about it is hepatization. The microscope shows much infiltration of the bronchus, and pus in its lumen, while within the alveoli and air-passages are pus and swollen cells. Several of its features lend themselves to the conclusion that early in its pathological change this portion of the lung became collapsed, and that the products of inflammation subsequently filled out much of its capacity, and the excess of blood in the vessels retired before its accumulation.

The hepatized masses disseminated through the lungs are devoid of air, cannot be artificially inflated, and, when carefully removed, sink immediately in water.

The histological examination of fully developed broncho-pneumonia shows that all the tissues have been involved.

The bronchi contain small spheroidal, nucleated cells, small cells in various stages of degeneration, desquamated, swollen epithelium, and granular matter. The mucous membrane is swollen. Its superficial layer of epithelium may be partly or wholly detached. Subjacent layers are separated and infiltrated with small spheroidal, mononucleated cells. The connective tissue beneath the epithelial layer is closely packed with small spheroidal

Fig. 2068. Part of the Wall of a Bronchus: Lobular Pneumonia of Children, showing Section of Infiltrated Bronchial Wall. × 850 diameters. (From Delafield.)

cells. The same is true of the connective tissue without the muscular ring. Its fibres are everywhere separated by the same small cells, whether leucocytes or proliferated connective-tissue cells. The abundant stroma of the child's lung, the connective-tissue framework, is infiltrated, and forms a distinct separation of the lobules and groups of lobules and alveolar walls. In addition to ordinary diffuse infiltration, the septa have within their lymphatic spaces extensive collections of cells and serous fluid.

The intra-alveolar products of inflammation are, as has been repeatedly said, mostly cellular. There are present large flat epithelia, similar to those adherent to the alveolar walls, large swollen spheroidal and polygonal cells, small round spheroidal cells mononucleated, and cells of like size with nucleus broken down, to which is commonly given, in medical pathology, the name of pus. In addition there is in many lungs, in scattered portions, fibrin. This may exist throughout the extent of the consolidation, and may be extensive in amount, or it may be small in amount and present only in scattered regions. Its extent is never so great as in the pneumonia of adults, and in many cases it is absent. The blood-vessels so richly distributed in the bronchial and alveolar walls dilate, become distended, tortuous, and looped, and occupy a considerable portion of the consolidated mass. Granular matter and serous fluid make up the remaining elements of consolidation.

Tissues wholly infiltrated have a liver-like feeling, and, like the liver, have a stroma packed to its utmost with cells. When subjected to pressure of the point of the finger, the tissue gives way, as would frangible liver-tissue, and allows the finger to enter.

The bronchial glands are ordinarily swollen, congested, and in a condition of hyperplasia. It is not infrequent to find in them miliary tubercles—even when these are not found elsewhere.

2. *Lobar Hepatization.*—Here we have a picture not unlike that presented by the lobar pneumonia of adults. The distribution of the hepatization is lobar. It may occupy an entire lobe, usually the lower lobe of both sides or of either side. It may also, and frequently does, in addition, affect the posterior portion of the upper lobe. It is commonly developed later than the bronchitis, but, clinically, many cases appear to indicate that the pneumonia is diffuse and involves all the tissues simultaneously. In such cases the bronchi are infiltrated and the hepatization rapidly becomes complete.

The pleura may have the following appearances: It may be dull, lustreless, "sand-papered" in appearance, or covered with a delicate pellicle, or coated with a distinct layer of fibrin, or even well-marked exudation may be present, the lesion then deserving the name pleuro-pneumonia. The color of the lung is uniform, varying from a dark mahogany to a dark violet, or it may be marbled. The limits of the lesion are not definite. It usually does not involve the whole lobe, the anterior portion commonly escaping. The cut surface is smooth, scarcely moist, dark blood flowing from the open mouths of the vessels. It is not distinctly granular, like the cut surface of the lung in the lobar pneumonia of adults. There is fibrin in each, but the child's lung has much less, and by no means enough to mass the contents of the air-spaces into fibrinous plugs. On pressure frothy muco-pus escapes from the bronchi. Such lungs have most of the gross appearances of the lobar pneumonia of adults. However, there are to be found, here and there throughout the organ, lobules or groups of lobules still aerated, and in the lingula and sharp edges a condition of carnification may be noted. Many lungs exhibit in different parts types of all the stages and characteristics of broncho-pneumonia here described.

The presence of fibrin again likens the condition to lobar pneumonia of adults, but the fibrin is seldom so abundant, and the cellular element predominates; the bronchi are infiltrated, pus separates the layers of connective-tissue septa and forms large collections, and infiltration of the walls of the air-passages and alveoli is added to the former pictures. Here, again, we find pus and large round nucleated cells in the alveoli, pus in the bronchi, swollen cells yet undetached from the alveolar walls, and congested vessels, but not the tortuous, distended vessels described with carnified lung. Here, again, fusiform dilatation of the bronchi is frequently found. The mucous membrane is reddened, and its surface is covered with thick muco-pus in the larger and medium-sized bronchi, and with pus in the smallest. These dilatations are widely distributed in the lower lobes, but they are not excessive in size. They may closely simulate abscess, and have often been so named. The microscope, however, shows the remains of a thinned wall continuous with the bronchus.

The hepatized lobe is moderately distended, its surface is raised or level with the surrounding normal lung-tissue. Its color may depart from the usual brown and be dull gray or mottled. Excess of pus in the alveoli, in the inter-lobular septa, in the bronchi and bronchial connective tissue, may express the blood from the vessels, as in the artificial experiments referred to, and distend the surface above the neighboring tissue. The microscope shows pus everywhere. In the lymphatic spaces it may be gathered in pools. With this background, the infiltrated bronchi have no contrasting color, and thus to the naked eye exhibit no marked lesion. It would seem as though the process were sudden and diffuse. In general the description of the hepatized masses in disseminated pneumonia will answer for the description of the mass of lobar distribution.

Here, again, I desire to repeat that the pneumonia of childhood, and by that I mean of children under three years of age, and at most under five years, is unlike the pneumonia of adults. The tissues of the child are more nearly embryonal and tend to cell proliferation; the connective-tissue stroma is abundant and disposed to infiltration by proliferation of its own cells and by the presence of leucocytes, and the bronchi are in excess. The blood-vessels are but loosely held in the alveolar walls, and play a part which has no likeness in the morbid anatomy of adults except in the lung of heart-disease. They assume the looped and snarled condition in both.

This contribution is written after an experience of from five hundred to six hundred autopsies on children dying of pneumonia, and in the midst of an extensive and fatal epidemic of measles and broncho-pneumonia in the largest children's hospital in this city; and these anatomical characters of the disease have been observed with care and amply verified by competent observers.

Resolution.—The pneumonia of childhood has no distinct stages corresponding to those of so-called croupous pneumonia of adults. It develops by irregular invasions of successive portions of lungs. In like manner it resolves. The consolidated mass may easily contain all the stages commingled, and the mottled appearance so often referred to may be caused by the presence of lobules of gray and red hepatization lying side by side. It is easy to see that there is then no distinct stage of gray hepatization. In the lobar pneumonia of adults the fibrin is the first element to disintegrate and be absorbed, the cellular element the last. In broncho-pneumonia, where the product of inflammation is mostly cellular, it is not surprising that resolution and absorption are slow —and such is the fact. In the broncho-pneumonia of children there is no well-defined stage of resolution.

Many children dying of acute pneumonia at the age of two to three years reveal firm old adhesions, relics of former pneumonias. The apices of these lungs show no sign of persistent lesion, and the bronchial glands are affected only by the recent inflammation. Recovery is slow, even in favorable cases, the infiltrated bronchi being the last to return to the normal standard.

Chronic Broncho-pneumonia.—Instead of resolution and a slow return to normal, the pneumonia may persist. The proliferated cells take part in the formation of new connective tissue, cicatricial tissue, and thus cause permanent thickening. The infiltrated septa reaching to the pleura and the alveolar walls of certain portions may become similarly thickened. The walls of the bronchi and their surrounding tissue are especially subject to a permanent thickening from the formation of new connective tissue, constituting chronic bronchitis and peribronchitis.

The bronchi, already dilated, become still more so by contraction of the cicatricial tissue surrounding them. The uneven contraction of this new tissue, together with the pressure within the tubes, favored by a weakened condition of the walls, allows of saccular as well as fusiform dilatation of the bronchi. The epithelial cells of the dilated bronchi proliferate and add themselves to the abundant pus; the epithelium remaining is swollen, deformed, and loose, giving a condition not unlike an ulcerated surface in the saccular dilatations. To this condition, as in acute broncho-pneumonia, the name abscess has been given, but its use leads to confusion and is not to be encouraged. Such cavities may become obliterated entirely in time, or may contract partially upon their contents, which become at length yellow, dense, dry, and glandular in appearance. The cut surface of such a lung often presents the appearance of a sponge filled with pus, and on pressure the likeness is still further increased by the welling up of pus from the numerous bronchi of varying size.

A most serious lesion, and one frequently associated with chronic broncho-pneumonia, is found in the bronchial glands. It is tuberculosis. There may be extensive cheesy masses within the enlarged glands, or the whole extent of the gland may be cheesy, or the centre may be broken down and contain creamy fluid.

The lesions of chronic broncho-pneumonia within the lung are often associated with tubercular lesions, in the form of diffuse tubercle and tubercle granules.

It has been stated by former writers that caseation is among the results of chronic broncho-pneumonia, but it is probable that the lesion referred to was due to the later stages of tuberculosis, associated with, or following, the broncho-pneumonia.

The bronchial glands clustered about the main bronchi and roots of the lungs are, as a rule, large and congested, having a dusky hue. These give rise to no symptoms, and deserve little attention, except in connection with chronic pneumonia. They may enlarge to six or eight times their normal size, and yet show no lesions which may not allow them to return to their former dimensions, the condition being simply one of acute hyperplasia.

Emphysema.—A frequent accompaniment of broncho-pneumonia is the development of emphysema. It is usually vesicular and situated at the anterior portion of the upper lobes. It is due to the diminished amount of air-capacity, together with the violent introduction of air into the chest in dyspnœa and coughing. In the normal lung the alveoli are invisible to the unaided eye. In emphysema they are so distended as to be plainly seen. It is exceedingly difficult to gain by the aid of the microscope any further information in emphysema vesicularis. It is believed that the vesicles are distended and dilated, but it is also believed that they return to the normal on the subsidence of the lesion which caused the condition. It is believed, too, that they rupture into each other. But they are mostly uniform in size, and, as has been said, return to their normal size in the child recovered from pneumonia.

Emphysema, both vesicular and interstitial, is found more commonly with the pneumonia following whooping-cough.

The interstitial variety may exist as superficial sacs, formed by rupture of air-vesicles beneath and lifting the pleura, or it may extend between the lobules in V-shaped tracts, from the anterior edge of the upper lobe even to the root. The vesicular and interstitial emphysema is most commonly of the upper and anterior portions of the superior lobes.

Etiology.—Among the *predisposing causes* of broncho-pneumonia none should be considered more important than that of age. Under five years of life, the pneumonia is usually of this type, whether it occurs as a primary lesion, or whether it complicates measles, scarlet fever, diphtheria, or whooping-cough. As a secondary lesion, it is not uncommon to find it later than the fifth year. Pneumonia earlier than the sixth month is less common, on account of greater care and less exposure of infants and their comparative immunity from diseases favoring bronchitis. Dentition and rapid growth, associated with tendencies toward catarrhal inflammation of the air-tubes, are also favorable to the development of pneumonia.

The sexes suffer equally from the affection. Children of enfeebled constitution, or those debilitated by previous disease, come at length to a condition of constitutional predisposition. Tuberculosis, chronic diarrhœa, rickets, and impaired nutrition, from whatever cause, act as predisposing agents. Certain seasons of the year, coinciding

with those favorable to the development of bronchitis—cold, moist atmosphere with great variations of temperature, such as are found from January to April, inclusive—are predisposing. The following causes are also of importance: weakened respiratory power, impure air, poor and insufficient food, bad hygiene, poorly ventilated and overcrowded rooms in cold seasons.

Measles, scarlet fever, diphtheria, and whooping-cough find expression on the mucous membrane of the respiratory tract, disarm the guarding epithelium, and throw down the defences before the enemy. Measles creates a peculiar predisposition to broncho-pneumonia. The active causes of broncho-pneumonia include the pernicious practice of allowing infants to lie in wet garments, and of allowing debilitated infants to remain too continuously lying on the back. Among the rich, whose children have care and comforts, there prevails the practice of clothing the children in garments which allow exposure of the limbs.

Mechanical, chemical, and septic irritants, irritating gases, irritating dust, metallic or vegetable, dust from articles dyed in arsenical compounds, secretions of the mouth, particles of food (*Schluckpneumonie*), foreign bodies gaining entrance to the lungs, air inspired over diphtheritic and gangrenous tracts, serve as active causes.

In considering the *exciting cause* we find ourselves face to face with the unsolved problem of specific germ-infection. It is believed that this paper appears at a time when any day may be chronicled the discovery of the germ which engrafts broncho-pneumonia upon measles. Pneumonia cannot be an inherent part of measles, diphtheria, or whooping-cough. By some process of physiological evolution, these diseases seem to render the system vulnerable at certain points, and to transform the bronchial and pulmonary epithelium into a fertile soil. The dust of a hospital ward may furnish the germ, or the atmospheric air may envelop the child in a germ-laden medium, and yet the system escape infection. But some general debilitating cause, some forerunning specific infection may weaken the defences and deliver over to the germ of the privileged complication the previously safely guarded tissues.

Symptoms.—There is no other disease, except possibly typhoid fever, in which the symptoms are so varied and irregular, and admit so little of practical classification. For convenience of description, we divide the outward manifestations into those arising from the lesion of the bronchi, and those of hepatization or pulmonary lesion, including under the former some discussion of certain general symptoms.

Capillary Bronchitis.—The early symptoms of broncho-pneumonia are most commonly seen by the physician when following cases of measles, whooping-cough, and diphtheria, and to discuss the symptoms apart from these circumstances is to make too easy the early diagnosis of the most fatal form of the disease under consideration.

Râles appear early and give the most accurate information of the advance of the disease, its extent, and its severity. They are coarse or mucous, or bubbling, sibilant, fine or subcrepitant, or crepitant. The râle is modified by the portion of the bronchial tree affected, by the amount of congestion and infiltration and by the consistence of the muco-pus.

In an early stage, when the advancing infiltration has left behind the bubbling, coarse râles of the large tubes, and it invades the smaller tubes and narrows still farther their calibre by congestion and infiltration, the presence of the viscid mucus, yet containing little pus, occasions a sibilant râle both on inspiration and expiration, though more especially the former. It may be made to disappear after coughing. The crepitant râle announces the presence of the inflammation in the air-cells. It is a fine, dry, crepitating rhonchus heard in inspiration, and is best developed by coughing or by deep inspiration. Pure crepitant râles are less often met with in children than in adults.

In short, the low-pitched or bubbling râles are generally believed to be developed in the trachea and large bronchi, the high-pitched sibilant in the smallest bronchi, or those narrowed by infiltration, and to be due to vibration of viscid secretions in the tubes. A cough may displace the mucus and cause the rhonchi to disappear at the same time. On the other hand, the crepitant râle is believed (Walshe) to be due to the sudden and forcible expansion of air-passages and air-cells, and perhaps terminal bronchi, glued together by pathological secretion.

It is often easy to follow an advancing bronchitis through the above steps, after laryngeal diphtheria, but less easy to do so after measles.

The rhythm is disturbed. Instead of the inspiratory murmur being nearly continuous with the expiratory, the pause which in health was after expiration and before inspiration, is now transferred and is after inspiration and before expiration. The child quickly draws its breath, holds it, then with an explosive, grunting sound, expires, and without pause again inspires. The expiration is prolonged and loud. The muscles of the abdomen are brought into play to increase the force of expiration.

Another disturbance of rhythm is the temporary suspension of respiration. For any fraction of a minute a child may pause in respiration. In resuming the function it may draw a deep breath, rapidly follow it with short respirations, gradually growing shallower and shallower till respiration again ceases; after momentary suspension the child again draws a deep breath, traversing the circuit from sigh to suspense again and again. Or it may, after the pause, resume breathing by short shallow respirations, followed by suspense. Or a third form may present itself. After the pause, the round may begin and end with short shallow respirations, having first an ascending scale to the deep respiration, and descending subsequently by similar short, shallow and shallower respirations to the pause. These irregularities in rhythm have been described by two observers, whose coupled names give to the peculiar phenomenon the name of "Cheyne-Stokes" respiration.

Rilliet observed a child of two months, the pause in whose respiration lasted several minutes, and supposing it to be dead he left it. To his astonishment, he, some hours later, found the child still living, and it continued to live till the following day.

Fever. Broncho-pneumonia has no characteristic fever-curve. It is unlike the lobar pneumonia in the adult in this respect. In the early stage, while the lesion is mostly confined to the bronchi, it is of the type of catarrhal fever, *i.e.*, remittent and intermittent, later becoming continuous. In rapidly developing diffuse pneumonia it may become high and continuous from the first.

As the parenchyma becomes involved and the crepitant râles appear, there is a high and continuous fever of the inflammatory type. The original or primary disease influences the character and intensity of the fever.

Of all the signs to be observed, those which most often serve for diagnosis, when taken together, are rise of temperature with the development of high-pitched crepitant and subcrepitant râles heard at the bases of both lungs behind, the seat of election of broncho-pneumonia.

The signs of consolidation seldom appear before the third day of the bronchitis, and usually from the third to the eighth day.

The distinct vesicular murmur, puerile breathing of children, may become modified in labored respiration. Between the scapulæ, in the neighborhood of the bifurcation of the trachea especially, is the effect well marked. Here the broncho-vesicular breathing, which is faintly heard in health, becomes distinctly tubular in dyspnœa.

Cough. This is a constant symptom. From the first of invasion to and beyond the last of resolution, the little patients are afflicted with this symptom. At one time it is dry, short, and worrying, at another it is paroxysmal, resembling whooping-cough. Even after resolution is complete and the patient seems to have recovered the cough may persist, may be paroxysmal and distressing, and add to the fear that tuberculosis is present.

Respirations. In infancy and childhood the rhythm and frequency of respiration are early and regularly disturbed in broncho-pneumonia. From the first appearance of acute bronchitis the number of respirations in-

creases, until in capillary bronchitis they amount to eighty per minute. It may be stated generally, that marked increase in respiration is due to bronchitis, and increase in temperature to pneumonitis.

The physical signs are not in strict relation with the dyspnœa. A severe dyspnœa, due to a deep-seated lesion, may find but insignificant expression at the surface. So in diffused pneumonia with high temperature, the dyspnœa may be inconsiderable.

Periods of great depression, coming on suddenly and departing equally suddenly, have been attributed to congestive attacks and collapse of limited and scattered areas of lung-tissue. Although this is one of the points so difficult to substantiate in post-mortem studies, it seems a reasonable explanation of the phenomena. Success in treatment of this condition still further leads to this conclusion.

The lesion of capillary bronchitis is essentially asphyxiating in its effects, and manifests itself by lividity of the extremities. When this has proceeded far enough to produce a paralyzing effect on the nervous distribution, impairing the sensitiveness of the respiratory tract, it is to be expected that the efforts to free the tubes of their contents will cease. So, in fact, they do. Coughing ceases, respiration ceases to be jerky, but is still rapid, or may diminish in frequency. So far the patient appears to be improving. Very soon the burden on the right heart becomes excessive, the lividity increases, the extremities become cold, and the heart's action is rapid and feeble. The staring, rolling eyes, the restlessness followed by inability to clear the trachea or larynx, are noted, the "filling-up" is at hand, and the "death-rattle" announces the close of the scene.

The duration of the disease in fatal cases, from the time it is fully established, may be from twenty to fifty-five hours to several days, depending on the age of the patient and the severity of the disease, that following diphtheria being unusually fatal.

Brain symptoms may be so prominent, together with opisthotonos, as to lead to the diagnosis of cerebro-spinal meningitis. I have been called to make autopsies on such cases, expecting to find the lesion in the brain and cord. A recital of the symptoms included a good picture of such a lesion. Especially does double pneumonia with pleurisy or pericarditis simulate it closely.

Disseminated Broncho-pneumonia.—By this classification is meant those forms of pneumonia occurring as irregular consolidated masses in any portion of the lungs. They comprise the more common conditions as observed apart from the severe epidemics, and also the pathological condition known as carnification.

It is important here to bear in mind the general progress of broncho-pneumonia. The catarrhal inflammation of the trachea and bronchi may advance slowly and invade the capillary bronchi irregularly, and develop successively pneumonic masses in separated portions of the lung. It has elective regions for its greatest development, and here the masses may be closely gathered together and give signs of their presence.

Here, again, it must be remembered that the main branches of the bronchi are given off at such angles, at the root of the lungs, as to catch the drain of the trachea and bronchi, and their dependent branches are again given off to the very lowest portion of the lung. This applies to children lying in bed.

We, then, are coming to consider a bronchitis which involves the capillary bronchi, and has passed in places into groups of lobules, here and there giving rise to disseminated pneumonitis.

As a result of gravity, in the case of children lying in bed, we find the posterior margin of the two lungs liable to receive products of inflammation from the air-tubes, and to take on an indolent inflammation combined with collapse. Whether the received pus can act as a sufficient irritant to start the inflammation, or whether a specific bacterium descends with it, will doubtless be known at no distant day. It may be facilitated in its action by plugging the bronchus and producing collapse. We feel that this paper will hardly be before the profession before some one may have settled the question of the pneumococcus.

It is in this form of pneumonia that the diagnosis is found so difficult. On percussion the note may seem to indicate dulness, first in one place, then in another, and the diagnostician concludes at last, either that there is no pneumonia or that it exists equally on the two sides. There may be moderate dulness of both sides, not omitting the apices. The fever may have crept up somewhat with the bronchitis, but is not above 102½° F., and may not seem to indicate any addition to the previous disease. Respiration may be so little increased as to render the diagnosis again difficult. There is, in short, a moderate increase in the frequency of respiration and in the temperature, and there are physical signs of uniform dulness behind, with exaggerated puerile breathing, and with coarse and sibilant râles in abundance.

The pneumonia of marasmic infants belongs in this class. In fact, it is desired to group here all those varied types which have neither the asphyxic tendencies of the type designated under capillary bronchitis, nor, on the other hand, the strong sthenic characters of the type to be later mentioned.

Generalized or Lobar Pneumonia.—In this form the grouping together of a sufficient number of hepatized lobules gives physical signs similar to lobar pneumonia—dulness, bronchial breathing, and bronchophony. It is unlike it in these respects, viz., it does not develop so abruptly and define itself at once, it is seldom confined to one lung, does not fill the whole lobe, and does not run a short course ending in crisis, followed by speedy resolution.

It is regularly a secondary lesion. It creeps on insidiously, its first signs being increase of cough, increased dyspnœa, the respirations becoming jerky and grunting, pulse full and strong with moderate increase in rapidity, skin hot and dry at first, later becoming bathed in perspiration. It does not usually attain its height in twenty-four hours, but in the course of several days. It is seldom ushered in with a chill. Convulsions may mark the onset of the attack, if abrupt and severe. This is, however, unusual. The fever is intense and of continued type, reaching 105° to 107° F. It may vary from 104½° to 105½° F. for from four to twelve days, rising abruptly to that height and at last descending gradually. Respiration is increased in rapidity, but not to such an extent as in capillary bronchitis. It may reach forty per minute, and, in the so-called congestive attack, fifty or sixty. Its character is modified by accompanying pleurisy.

The expiratory moan is believed to be due to the pain arising either from the movement of the lung itself, or from the friction of the two folds of the pleura. The expiratory moan is not wholly pathognomonic of pneumonia or pleurisy, for painful respiration from whatever cause may give rise to it. The countenance has an anxious, drawn appearance. The cheeks take on a bright blush, either both or one, indifferently. The eyes are bright and roving, in keeping with the general condition of unrest.

On *auscultation* the earliest signs of pneumonia are to be heard at the base of one or both lungs, behind. Subcrepitant and crepitant râles appear in abundance. After from two to four days bronchial breathing is heard, first on one side and in moderate extent, later on both. Its early stage may be dry, or accompanied by fine râles and, later, by a mingling of coarse and fine. Extensive consolidation of one lung may transmit the auscultatory signs from the opposite side and easily lead to confusion.

Percussion in very young children may give a modified dulness. There is however a sense of resistance communicated to the finger, quite characteristic and instructive. In noisy surroundings, such as attend most clinics in a large city, this sense aids very materially. When fully developed, the physical signs of broncho-pneumonia of lobar distribution are not unlike those of pure lobar pneumonia of adults. Its difference is easily determined by the clinical history. It is a secondary disease, it is preceded by bronchitis, develops slowly, and signs of disseminated pneumonia are to be found in other

parts of the lung. Convalescence is slow and prolonged. The strength is impaired, the child is emaciated, the eye is sunken even though the disease has run a course of but few days; early convalescence shows how seriously the patient has been exhausted by the fever and labored respiration. The patient is irritable, not inclined to move about, is without appetite, and regains flesh slowly. The cough is persistent and annoying. The duration of the disease cannot be stated with any precision. If death is the final issue of the pneumonic process purely, it usually arrives on the third to the eighth day. It is not uncommon for the signs of consolidation to begin to disappear on the eighth to the twelfth day, even yet to be followed by long convalescence.

Pleuro-pneumonia deserves mention under this heading. In severe epidemics of measles the complication of pleurisy, with the production of fibrin, serum, and pus, plays an important rôle. Its symptoms are superadded to those of consolidation, and instead of dulness it is possible now to have flatness. It is nearly always limited to one side. On auscultation the lung may be found compressed against the vertebral column, giving bronchial breathing and voice for a limited, well-defined space. This bronchial breathing may be of a blowing variety, extending from base to apex and from two to three inches in width, vesicular breathing being present only at the apex.

The differential diagnosis of pleurisy and pneumonia in infants is often impossible. This has been the conclusion where several competent observers have examined the same cases, and each case has been subsequently examined post mortem.

Diagnosis.—For differential diagnosis we are brought to consider carefully the previous history of health or predisposing disease, its beginning with bronchitis, relation of pulse to respiration, slow developing of masses of consolidation in elective positions, dyspnœa, character of the fever, its prolonged course, and absence of crisis.

It is unlike lobar pneumonia, with its abrupt beginning, with its characteristic high temperature, ending in crisis and rapid resolution. Lobar pneumonia is not preceded regularly by predisposing diseases, nor does it begin with bronchitis. Moreover, true lobar or croupous pneumonia is a rare disease in infants and children below five years of life.

Acute disseminated miliary tuberculosis may simulate many of the signs of lobar pneumonia, and its differentiation cannot be made by rule. For comparison with the above, the reader is referred to the article on Tuberculosis.

It may be pertinent to state that severe pleuro-pneumonia may simulate strongly cerebro-spinal meningitis.

Prognosis.—Broncho-pneumonia of infancy is an exceedingly fatal disease. The gravity of the prognosis varies, however, in the following particulars:

It is most grave after whooping-cough in infants, and the younger the child the more fatal the disease.

Next in gravity is the pneumonia after measles, in which Ziemssen gives fifty per cent. of deaths.

Close upon this comes the pneumonia with diphtheria. It is not easy to determine which is the cause of death in this combination. Patients recover having had both, and in case of death diphtheria seems to be an efficient cause.

Age is important before other considerations. Ziemssen lost one-half of his pneumonia patients under one year of age; two-fifths of those from one to three years; one-fourth of those above three.

Pneumonia which develops quickly tends to a speedier resolution, and affords a favorable prognosis.

Previous existence of rachitis, tuberculosis, feeble constitution, and surroundings of poverty, allow the resolution to become prolonged and the patient to die of exhaustion. The conditions of crowded hospitals may be classed as unfavorable surroundings.

It is believed by many that fat children have less resistance to broncho-pneumonia, not having so much blood in proportion to their weight as a well-nourished child having less adipose tissue.

The prognosis is unfavorable in cases where early suffocative symptoms are prominent.

Further unfavorable symptoms are, a sudden fall of temperature, with rapid and feeble pulse, irregularity of pulse, slowing of respiration, Cheyne-Stokes respiration, sudden disappearance of cough, and restlessness giving place to stupor or delirium. These mark the last stage of a fatal case.

Treatment.—The treatment of this disease is symptomatic. It is not believed that anything is able to cut short pneumonia once begun. If one is happily the observer of a case once entered upon its course, which suddenly resolves and disappears, let him remember that nothing is too irregular to be the course of pneumonia in children.

Careful attention to nursing is of the first importance in this severe struggle for life. The child should have its bed in the middle of a large room, well lighted with several windows, by which also air may be admitted without creating a sensible draught. It is not uncommon to find the child in a small bedroom opening off from the family living room. This cannot be well lighted nor well ventilated without creating a current of air which will strike upon the patient. A child harassed with cough, tossing with fever, soon gets its clothes misplaced, often encircling its thorax with a tight band of crumpled garments interfering with free respiration, and rendering its restlessness more active and exhausting. If the chest is swathed in any local application, it may be found in a rope-like band under the arms, while the body and legs are exposed. The child alternately sleeps and tosses in this condition.

When it becomes exhausted, or if the child is quite young, it lies upon its back immovable for hours, or mostly for days. It is not strange that we often find pneumonic consolidation having its anterior margin in all the lobes of the two lungs limited by a well-defined horizontal line.

The child should be frequently turned upon its side, held upon its nurse's shoulder, carried, laid upon its face across the lap, held over the arm while rocking, as far as its strength will permit.

Attention to the comfort of the little patient often secures to it rest and sleep. Straighten its clothing, rearrange its pillow and covering, bathe it in alcohol and water under the clothing without exposure, or, if its skin is dry and hot, rub it with sweet oil, moisten its lips, do the countless little services which do not put drugs into its stomach.

All these precautions would hardly seem worthy of mention did we not see them neglected every day, and paregoric administered in lieu of them.

Often, having secured to the room air that contains enough oxygen and enough heat, it is well to add moisture by whatever means. Dry air allows the mucus sooner to become thick and tenacious. We find older patients express their gratification and relief on being allowed to breathe steam. It is well to have a wide, shallow vessel generating steam near the patient. A teakettle over a grate fire, with a conducting tin tube, will furnish steam to the patient more uniformly than can be done by ordinary means, or a shallow vessel may be kept over a gas-stove. It is well to add that steam will not take the place of oxygen. Vitiated atmosphere with added steam is a most unfortunate combination to a patient with labored respiration.

For artificial food there is nothing better than milk. Two to four pints a day may be given, according to the age of the patient. Prepare the milk by adding one-fourth lime-water, and administer it at short intervals in small quantities. When the parents ask what the child shall eat, explain that the milk is food. When they declare that the child cannot take it, say that it is medicine and must be taken. Many times a cup of milk may be given every two hours as a medicine, when it would fail as a drink. Kumyss is often borne by irritable stomachs when other foods are rejected. The numerous peptonized or pancreatized preparations of milk serve a useful purpose.

The symptoms, which may demand treatment, group themselves according to the anatomical classifications al-

ready defined. They are those of bronchitis, hyperæmia, and hepatization of the lung, dyspnœa, suffocation, painful cough, fever, and exhaustion or adynamia.

Among the alarming symptoms of the early stage are the labored dyspnœa and impending suffocation, especially in children under two years of age. What can be done with such a tiny patient? Its bronchi are narrowed by swollen mucous membrane, their calibre is obstructed by tenacious muco-pus, and death seems imminent. Nothing meets so well the indications as some agent which shall promptly produce vomiting. The mechanical act removes more or less mucus from the bronchial tubes. The agent of most avail is ipecac. By its action as a nauseating agent and emetic it increases the flow of mucus, and by its inducing vomiting it tends to remove it. The lungs are held firmly in the grip of the fixed thoracic walls, while the abdominal muscles force up the diaphragm and squeeze from the sponge-like organ the contents of its main avenues. Besides, ipecac is well known to excite secretion independently of its action as an emetic and nauseant, and its administration is followed by little depression.

According to age, powdered ipecac may be administered in doses of from five to fifteen grains. For a child of one year five grains in whatever vehicle (sugar-water is often used), followed by draughts of lukewarm water, will usually produce vomiting and temporary relief. This may be regularly administered morning and evening to secure more uniform relief, for one or two days. If, at length, the usual dose fails to induce vomiting, but is rather followed by diarrhœa, the remedy must be abandoned. Often doses of a single grain, conveniently put into sugar-of-milk tablets, are easily taken by the patient, and serve to liquefy the mucus and relieve the less distressing symptoms. Indeed, the vomiting effects should be reserved for the urgent symptoms of suffocation, and the repetition of the dose should be undertaken by the physician himself. He should bear in mind that blunted sensibilities, arising from asphyxia or whatever cause, may not respond to the nauseant.

Warm baths deserve the next place in the enumeration of agents to relieve the urgent dyspnœa of broncho-pneumonia. In speaking of this remedy for this symptom it must be remembered that the majority of cases occur in the first two years of life, and the method must be adapted to the tender years of infancy. An infant laboring for breath is wearied and exhausted by handling. For saving its strength it is often desirable to adopt some such method as the following: Prepare a bath of such capacity that the child may be submerged up to its chin. Among the lower classes the laundry tub is usually convenient in a warm portion of the tenement. The water should be about 100° F. Lay the child, deprived of all its clothing, in a large towel lengthwise, gathering the ends of the towel above the head and below the feet. The child is then lying easily in an extemporized hammock. Gradually sink this into the water, at the same time bathing the face with the same water. With a little care the child accepts the situation without fright, and soon finds relief. After from five to fifteen minutes the child is removed in the hammock and laid in the wet towel within a woollen blanket, and allowed to rest for a few minutes, or for as long as two hours, if it sleeps and if its hands and feet continue warm. In this way I have seen the temperature of a child eight months old reduced from 108° F. per rectum, with continued convulsions, to 103° F. per rectum in four hours. Respiration became easy, the child slept, and went on to good recovery. The temperature sinks for some time after a warm bath, and allowance should be made for it. I have on one occasion seen a case of pneumonia following measles, kept in the wet pack three days and three nights with the greatest satisfaction. The child was the weaker of twins and less than three years of age. It is only fair to say this was in the family of a physician, and the patient had constant intelligent watching. Before the wet pack was tried dyspnœa was urgent, with beginning cyanosis. Within twenty minutes the restlessness moderated, the child sank into a quiet sleep, and the temperature, though never above 105° F. per rectum, became less and ranged about 102° F.

In the ordinary warm bath mustard may often be used with good results.

In suspected collapse of portions of lung in feeble young infants, some have practised inflation with benefit. Wrap the abdomen tightly with a bandage to prevent as far as possible inflation of the stomach. Apply the mouth over the child's mouth, compressing the child's nose between the thumb and finger, and inflate the lungs. The danger of emphysema is removed by the safety-valve of the œsophagus. I am not aware that any harm has been done by this method, but it has not met with general favor.

In hepatization and pleurisy the pain exhausts and adds to the dyspnœa, and doubly depresses the patient. The time-honored flaxseed poultice serves a useful purpose still. In order that it may not become displaced, it is desirable to fasten it above the shoulders and about the waist, taking care that it does not bind the thorax tightly and interfere with the proper expansion of its walls. The requisites of a poultice are that it be thick and hot, and be changed at the end of from four to six hours. Covering it with woollen cloth or oiled silk keeps it hot for a longer time. What accomplishes much the same purpose, without the exposure attendant upon frequent changing, is the cotton waistcoat. Take cotton-batting and cut a pattern of a waistcoat of such a size as will fit accurately below the chin, close about the neck and about the shoulders, and extend to the umbilicus. Stitch this to the outside of an ordinary flannel undershirt, so that next to the skin shall be the flannel undershirt with long sleeves; upon it shall be the close-fitting vest or waistcoat, and over this again some woollen wrapping. This protects and warms the surface, and perspiration escapes slowly. The symptoms relieved by the poultice are commonly relieved also by this means. In the hands of unskilled attendants, the cotton waistcoat exposes the patient to less risks than does the poultice. It is not claimed, however, that it is absolutely as good as a poultice well applied.

For the pain and cough which do not admit of rest, opium must be given; paregoric according to indications, or Dover's powder in grain doses, less or more, according to age and requirements.

No other two remedies assist so much in regulating the severe symptoms of pneumonia as the warm bath and opium.

Specific antifebrile remedies, under the consideration of the profession at this time, have a very useful function. It is not proved that they assist nature to throw off the malady, but they reduce temperature without danger to the patient, thereby affording rest, and guard against one dangerous symptom.

The method here recommended is to endeavor, by whatever means, to reduce the temperature, when high, to 103° F. Children bear high temperatures without the rapid prostration observed in adults. Thermometers mislead. If a child bears its temperature well, and yet the thermometer in the rectum registers 105° F., it does not mean that it must be dosed with antipyretics. Until we know nature's plans for relieving herself of the incubus, and especially when we see how successfully she usually accomplishes it, are we justified in teaching that when the mercury reaches 105° F., she is to be belabored? It is not necessary to go outside of New York to find children of one year in collapse, when the thermometer has pointed to ten grains of quinine and it has been given.

In the stage of resolution it is of advantage to stimulate the lymphatics by counter-irritants—painting the posterior surface of the chest with tincture of iodine. It is well to paint narrow parallel stripes, making the application often enough in the same line to effect counter-irritation. When this has begun to pass away, paint in like manner the interval of normal skin, till it in turn is irritated. In this manner it is possible to continue counter-irritation, and in case the surface becomes blistered by chance, a narrow blister heals more kindly.

Sinapisms, dry cups, and turpentine have each their

place among this class. Pleuro-pneumonia calls for such stimulation applied over the seat of the lesion, and this painting with iodine yields good results. Alcoholic stimulation calls for consideration among the remedies used in the later stages, when the powers of endurance are severely taxed. The excitement of fever has passed and the system is still burdened with the ashes and débris of the conflagration. A judicious, systematic use of some sweet wine or whiskey well diluted, administered in water or milk, is of service. In prescribing, it is better to advise a pure wine, regulating the dose after learning its strength and observing the indications.

In the stage of resolution the resources of the physician are often sorely taxed. The cough persists and assumes a paroxysmal type, followed by exhaustion. The patient, already much emaciated, refuses food, vomits after coughing, becomes paler and thinner. The flesh flaps upon its limbs, the lips are sore, the eyes are sunken, and in this sad plight it lies worrying, and moaning, and coughing.

Coarse râles are heard over both lungs, subcrepitant râles are also abundant. The percussion note may indicate the absence of marked consolidation and tubular breathing has disappeared.

At this stage the patient tarries, and convalescence is doubtful. Of course the ordinary food and tonics are prescribed—milk diet or fluid forms of meat, cod-liver oil, and quinine, but yet the change is slow. For this condition change of air seems to me the one thing desirable, especially for city patients. According to the season, a sojourn in the mountains, or removal to the seashore of the Southern States is useful. While waiting for convalescence to become established one is apt to reflect on the frequency with which the bronchial glands are, at autopsies, found to be tuberculous.

Cod-liver oil, by mouth or inunction, syrup of the iodide of iron, oxygen, quinine by suppository, mineral acids given at the same time or alternately, baths in tepid water in which sea-salt has been dissolved, and gentle massage, are of use in favoring the nutrition of these slow convalescents. Errors in digestion, especially the tendency to diarrhœa, may tax the ingenuity of the physician.

The persistent sweating is often relieved by a bath given at night, washing in warm water with soap, and subsequently with alcohol. Careful regulation of the feeding must be observed. Riding in warm, dry air, when the season permits, is useful.

Often it is preferable to have the child carried out on the arm of a nurse. It affords a healthful exercise to the child and keeps it warm.

When pleurisy is present and gives physical signs of effusion, little can be done beyond what has been recommended until the resolution has become established. Painting with iodine to the point of blistering, or a small blister by mustard leaf, is desirable. Here again I recommend a narrow line of irritation. Cut the mustard leaf so that it shall be an inch or less in width, and from four to six inches long.

If the child shows signs of septicæmia, or even fails to maintain its strength, the chest should be explored with a needle, and if pus is abundant aspiration should be performed. Empyema in children, having a generally favorable prognosis, is often put in the way of recovery by aspiration and counter-irritation. If this fails, it is not too late to open the chest and procure free drainage. The prognosis is in general good. The lung usually expands and perfect recovery takes place.

There are numberless drugs associated with the treatment of this disease, time-honored and possibly demanding mention. There are drugs to depress and drugs to stimulate, drugs to weaken the heart and drugs to strengthen it, drugs to loosen the expectoration and drugs to dry it, drugs to act as specifics, and quinine, which is at the vortex of all this whirling uncertainty. All these are to be held in readiness above the head of the tiny, restless sufferer.

The problem is to nourish the fever patient, restrain the severe symptoms which would endanger life, and in all ways to preserve the patient's strength. To accomplish this does not require the exhibition of a great variety of strong drugs, but does require careful nursing and wise direction.

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William P. Northrup.

PODOPHYLLUM (U. S. Ph.; Codex Med. [*radix de*]; *Podophylli Radix*, Br. Ph.; May Apple, Mandrake, etc.). *Podophyllum peltatum* Linn., order *Berberidaceæ*, whose rhizome and adhering rootlets constitute the above-named medicine, is a perennial herb of rather striking appearance. It has a long, cylindrical, nearly simple, dark-colored rhizome, scaly near the end, bearing along its upper side, at intervals of two or three inches, the successive scars of the stems of preceding years, with clusters of stout fibrous rootlets about them, and at its extremity the stem of the last year, with a bud at its base designed to continue the growth of the rhizome. The

Fig. 2969.—Rhizome and Rootlets of Podophyllum.

stem is smooth, round, green, or pinkish, from one to two feet high, and surmounted either by a single large peltate leaf, or by two leaves with a single, large, white, terminal flower between them. In the latter case the leaves are round-heart-shaped in general outline, pedately cleft into five or seven, or more, dentate or serrate lobes. Flower on a short, recurved peduncle about two inches in diameter; bracts three, fugaceous; sepals six; petals from six to nine; stamens twice as many; ovary one-celled, many-ovuled. Fruit a sweetish-acid, edible, oblong, juicy, yellowish berry, containing a dozen or more seeds, each partly enclosed in a fleshy aril.

Podophyllum is common in rich, moist woods in a large part of the United States and Canada, east of the Rocky Mountains. Its use in medicine dates back about a hundred years, although before this it is said to have been employed by the American Indians.

DESCRIPTION.—The dried rhizome is "about one fifth of an inch (5 millimetres) thick, horizontal, nearly cylindrical, consisting of joints about two inches (5 centimetres) long, somewhat enlarged at the end, which has a circular scar on the upper side, a tuft of about ten, nearly simple, fragile rootlets on the lower side, and is sometimes branched laterally; smooth or somewhat wrinkled, orange-brown, internally white and mealy, with a circle of small wood-bundles; pith large, inodorous, sweetish, somewhat bitter and acrid.

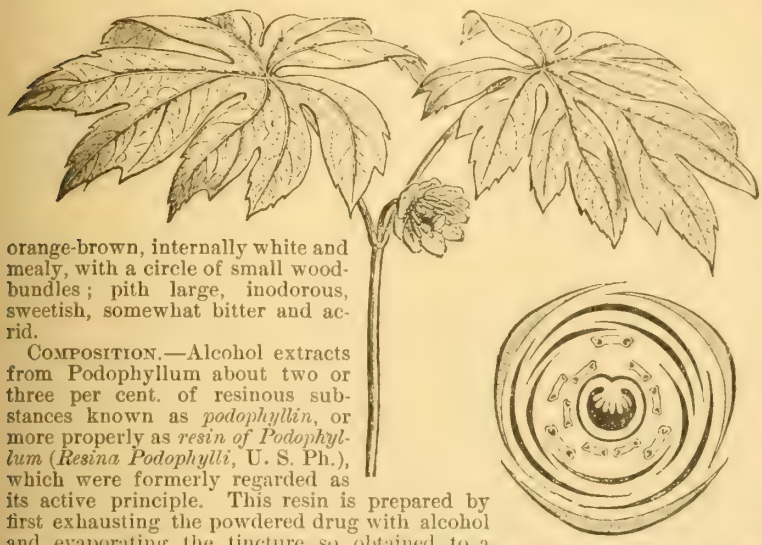

FIG. 2970.—Podophyllum, Flowering Plant and Plan of Flower. (Baillon.)

COMPOSITION.—Alcohol extracts from Podophyllum about two or three per cent. of resinous substances known as *podophyllin*, or more properly as *resin of Podophyllum* (*Resina Podophylli*, U. S. Ph.), which were formerly regarded as its active principle. This resin is prepared by first exhausting the powdered drug with alcohol and evaporating the tincture so obtained to a syrupy thickness, and then pouring this slowly into a large quantity of acidulated water, which precipitates the resin in the form of a brown or greenish-brown powder. It is then purified by further washing; it has a bitter, acrid taste, is partly soluble in ether, soluble in alkaline solutions, from which it is precipitated by acid, and melts at a moderate heat into an adhesive, resinous mass.

Besides this resin nothing of importance is found in the "root." It appears to be pretty well settled that the observations suggesting the presence of berberine in it were erroneous.

According to Dr. Podwyssotzki's researches, made a few years ago, this resin contains a considerable amount of *green, fatty oil*, a little coloring matter resembling *quercetin*, both of which are unimportant. Its principal active constituent is a white, amorphous resin, soluble in alcohol, ether, and chloroform, and slightly so in water, which he has named *podophyllotoxin*. This, in its turn, is composed of crystalline *picropodophyllin*, bitter and active, but insoluble in water, and of *podophyllinic acid*, which is inactive. These may be separated by treating podophyllotoxin with ammonia or lime, which unites with the acid and sets the picropodophyllin free.

ACTION AND USE.—Podophyllum or its resin is locally irritant, the dust occasioned by powdering the drug causing redness and smarting of the skin and inflammation of the conjunctivæ; it is an irritant cathartic, whether introduced into the bowels or stomach, given subcutaneously, or absorbed from a raw surface. It is a very slow-acting medicine, requiring from twelve to fifteen hours before its effects begin, but it is also rather persistent and thorough, and in full doses is followed by numerous watery stools. Griping pains are frequent accompaniments, and vomiting and persistent diarrhœa may follow if the dose is very large. After poisonous amounts the above symptoms are exaggerated, and inflammation and ulceration of the intestines, bloody stools, great prostration, stupor, and death may follow. The action upon man and the lower animals is essentially the same. It is supposed to stimulate the liver, and is very extensively given with a view to this effect, in the digestive disturbances called popularly "biliousness." While this action is scarcely proved of any of the popular cholagogues, Podophyllum, in common with calomel and a few other things, does appear to answer the indications pretty well. It may be associated with them if desired.

Podophyllotoxin produces in animals catharsis, vomiting, colic, and in large doses bloody stools, mucous discharges, salivation, great weakness, increase of pulse and respiration, collapse, coma, and death. Moderate doses given to man produce the same effects as podophyllum itself, with perhaps less pain and less tendency to vomiting. Picropodophyllin acts like the above, but less violently, in consequence, as is supposed, of its complete insolubility in water. Podophyllum and its preparations are, then, useful cathartics where action upon the whole intestine, or at least the small one, is desired, and where the liver is supposed to be inactive. They are frequent ingredients of "antibilious" pills, both of regular and irregular practice, and are frequently given, too, in small doses in "after dinner," and other mildly laxative pills.

ADMINISTRATION.—The powdered crude drug may be given; dose from one-half to one and a half gram (gr. x. ad xx.). But, in view of the great compactness of the precipitated "resin" (*Resina Podophylli*, U. S. Ph., etc.), this is to be preferred. The following preparations are in the Pharmacopœia: Abstract (*Abstractum Podophylli*), strength, $\frac{2}{1}$; Extract (*Extractum Podophylli*), strength about, $\frac{10}{1}$; Fluid Extract (*Extractum Podophylli Fluidum*), strength, $\frac{1}{1}$, and the beforementioned resin, strength about $\frac{20}{1}$, dose from one to three centigrams (gr. $\frac{1}{6}$ ad $\frac{1}{2}$). Of these preparations only the latter need be remembered or used. *Podophyllotoxin* can be had in the larger cities, and ought to be more uniform than either of the above, but is little called for. Dose about one-third that of the resin.

ALLIED PLANTS.—There is another species of Podophyllum inhabiting the temperate parts of Europe and Asia. For the order, see BARBERRY.

ALLIED DRUGS.—JALAP, SCAMMONY, and GAMBOGE resemble Podophyllum in action. See also other cathartics, as ALOES, RHUBARB, and CALOMEL.

W. P. Bolles.

POISONING: LEGAL ASPECTS OF THE SUBJECT.

This paper does not discuss the general principles of toxicology. The reader's knowledge of these is taken for granted. The nature of poisons, the distinguishing characteristics of the various kinds, the different modes in which they may be administered and will operate, the appropriate methods of detection—these and other branches of the subject are elsewhere treated. The present purpose is to state very briefly those peculiar duties of the practitioner which are connected with the use or misuse of poisons.

LEGAL DEFINITION.—For the purpose of what may be called legal toxicology, there is little need of establishing a precise definition of the term "poison." Medical authorities on the subject agree that the word is one very difficult (some say impossible) of precise definition. The law, in general, either leaves the question "What is a poison?" to be determined by judges or juries, under the counsel of medical men and experts, in view of the particular case which brings it forward for decision; or relieves the doubts and obscurity which hang over the word by associating others with it which may enlarge its scope. Thus an English statute passed early in Queen Victoria's reign (1 Vic. c. 85, § 2), says that whoever shall administer, etc., to any person "any poison or other destructive thing" with intent to commit murder, shall be guilty of felony. A trial under such a statute as this would not call for any lengthy discussion of the meaning of "poison;" testimony of experts, that the thing adminis-

tered was adapted, when administered in the way proved, to destroy life, would be sufficient on that point to sustain a conviction. On the other hand, if the experts doubted or disagreed, the judge would instruct the jury to give the accused the benefit of the doubt. Early American statutes use the simple word "poison," leaving the courts and juries to fix the meaning on the principles above stated. Thus in New York there are laws of long standing, punishing every person convicted of having "administered any poison to any human being;" and every person who shall "wilfully poison any spring;" and every person who shall "wilfully administer any poison to cattle," etc., or shall "wilfully expose any poisonous substance to be taken by cattle;" etc. The actual administration of even such laws as these does not turn on chemical or medical discussions of the precise meaning of "poison," nor vary materially with changes in the exact idea attached to it by men of science. Statutes passed in recent years specify what are deemed poisons; thus the Act of Congress regulating sales of poisons in the District of Columbia, names in two schedules the particular drugs intended; and of course, to sustain a conviction under such laws, there must be proof that one of the designated drugs was sold. Or, to put the idea in other words, the vital question in a trial at common law, as it is called, is not poisoning, but murder; did the accused kill the deceased by the drugs, etc., described in the indictment? In a prosecution under a statute punishing a particular form of poisoning, the question is, Did the accused do the act prohibited by the language of the statute, in the manner alleged in the indictment? Experts called in cases involving poisoning, are sometimes pressed to state by way of general definition, "What is a poison?" Such questions are unreasonable, except perhaps when put to test the witness' general knowledge and qualifications as an expert. The legitimate inquiry involved in the issue is this: Is the particular article or drug administered, one within the class prohibited by the statute or rule of law on which the accusation is founded, as that is commonly understood? A physician may not be able to give an exact definition, or to enumerate all known poisons, yet be perfectly qualified to give an opinion on a question of poisoning by arsenic, by strychnine, by laudanum, etc., and such are the questions involved in all ordinary cases. Again, there is no important legal difference between the meaning of "poison" and that of "deadly poison." Drugs which prove speedily fatal when taken in small doses, are characterized as deadly, but this is a mere matter of convenient classification. There is, however, a class of cases in which a general definition of "poison" may be important; they are such as arise under a statute which uses only "poison" to define the crime, without adding "destructive thing" or any similar term of enlargement; but the thing administered is not a poison in any correct sense, such as pins or needles, bits of sponge or wood, tufts of hair, orange seeds, or peel, cherry stones, raw rice, pounded glass, boiling water, all of which have been effectively used with suicidal or murderous intent. In these cases, the objection that the accused had not administered a "poison" would prevail; at least the question of the extension of that term would be legitimately involved. And generally, in inquiries as to criminal poisoning, the intent with which the noxious substance was administered is quite as important an element as is the nature of the substance.

Advertisement and Sale of Poisons.—The dissemination of advertisements of so-called remedies for procurement of abortion, framed in obscure, deceptive phraseology, has grown during the present generation to be a serious evil, and deserves to be mentioned as connected with the general subject of poisons. The regulation of the issuing of advertisements and circulars announcing such things rests wholly with the State legislatures and police. Congress has no power over that branch of the subject. Several of the States have enacted laws which, however, are not, as a general thing, very stringent or very efficiently enforced. The repression of the circulation of either the advertisements and the circulars, or the remedies themselves, devolves on Congress. The postal law, as in force at the beginning of September, 1887, and which operates, of course, over the whole country, excludes from the mails all poisons and every article or thing intended for the prevention of conception or procuring of abortion, or for any indecent or immoral use, and every written or printed card, circular, etc., advertisement or notice of any kind, giving information when or how such things can be obtained or made; and punishes by fine and imprisonment any person who shall deposit such things in the mails, or take them from the mails for the purpose of giving them circulation. Rev. Stat., § 3878, § 3893, as amended July 12, 1876, 19 Stat. 90. The duty laws forbid and punish the importation from abroad (a matter wholly within the power of Congress) of all kinds of abortives, and advertisements of them. Rev. Stat. § 2491, as amended March 3, 1883, 22 Stat. 489.

The selling of poisons, as distinguished from the mere advertisement of them as being for sale, does not belong to Congress (except as respects the Territories and the District of Columbia), but to the States. The laws are quite numerous and are varied in their provisions, but the general character of them is that they do not forbid, nor indeed restrain, the sale of poisons (in ordinary course of business of dealers), but prescribe a manner in which the vial or package containing a poisonous substance shall be labelled, and record made of the date of sale, name, residence, etc., of the purchaser. Independently of restrictions or penalties imposed by special statutes, the courts throughout the country hold dealers in drugs to a strict responsibility for sales of poisons made by mistake. A druggist who negligently sells a poison labelled as a harmless drug, and thereby causes the purchaser's death, is chargeable with manslaughter. That the error was merely carelessness is no justification; dealers in deadly drugs are held to a strict accountability for their sales. They must take the highest degree of care known among practical men, and are held to responsibility in dealing with poisons corresponding to the degree of knowledge required in the business. They are under a general implied obligation that what they sell is genuine, commercially pure, and fit for the use designed. A Kentucky druggist kept a mill for grinding drugs, and one day had need to grind some Spanish flies in it for a blister, and did so, not cleansing the mill properly afterward. Next day a customer brought a prescription calling for Peruvian bark, and the careless apothecary passed the bark through the same mill. It thus became mixed with a modicum of the dust of Spanish flies, and the unfortunate patient was made very sick. He recovered damages for the suffering and peril to which he had been exposed. The court said an apothecary is bound to know what he sells; and if Peruvian bark alone is called for, he must not sell bark mixed with cantharides (13 B. Mon., 219). More recently, another Kentucky druggist sold croton oil instead of linseed oil for a patient who died in consequence of the mistake, whereupon his widow was adjudged to have a right to full damages (11 Bush, 380). And there is a memorable case in New York State, where some manufacturing druggists put up belladonna in jars labelled, through mistake, "extract of dandelion." These jars were sold to retailers at random, and one of them, a druggist in Cazenovia, filled a prescription calling for extract of dandelion from this belladonna jar. The patient, a married lady, was nearly killed. As the Cazenovia apothecary acted innocently he was not prosecuted; but the husband sued the manufacturers, and recovered (6 N. Y., 397).

Poisoning, in Reference to the Distinction of Degrees in Murder.—In the legislation of many of the leading States during recent years, murder has been divided into two degrees, the general purpose being to class the more aggravated, deliberate forms of homicide, in the first degree, and make them punishable with death; while those exhibiting an instantaneous intent only, shall incur imprisonment for life. Murder by poisoning is eminently deliberate; in the statutes of several of the States—of Pennsylvania and New Hampshire, for in-

stance—killing by poisoning is expressly declared murder in the first degree; under other statutes it falls into that class by force of general terms employed to define the class, such as "wilful, deliberate, and premeditated killing." Under such statutes there have been one or two convictions for the second degree, where poison was unquestionably the means used for the homicide; but such convictions do not imply that poisoning is not in the view of the law deliberate; they rather show a compromise among the jurors; those who hesitated to join in a conviction which would be capital induced the others to unite in a verdict of the second degree rather than have a disagreement. The intent to kill is, however, essential under all accusations of murder by poisoning. In an Indiana case the accused administered a dose of cantharides to a woman, not meaning to kill her, but to excite her passions, so as to induce her to consent to sexual intercourse; but the dose was excessive, and caused her death. The decision was that, for lack of intent to kill, the crime was not murder.

The Importance and Difficulty of the Physician's Duties in cases involving poisoning can scarcely be overstated. His task involves intimate knowledge of chemistry, and often of law, as well as of practical medicine. The recovery of the patient if alive, the honor of the dead in cases of suicide, the reputation of the living in cases of suspected murder, may depend on the acuteness and energy, or on the prudence and reserve, of his measures. He must work, not only with friends and nurses, but often with persons shuddering or smarting under suspicion, and with jealous detectives, and with suspicious police. If he is called while the sufferer is yet living, his duties are complicated by the primary effort to effect a cure. If death has taken place, he may probably be the first person to detect any fleeting indications that crime has been committed, and is above all others best fitted to register and preserve the evanescent evidences. Moreover, with the progress of chemical science, the list of means at the command of the well-instructed poisoner is constantly extending, while the rapidity with which the methods of detection at the command of the practitioner are increased in number and complexity, renders his task steadily more difficult and responsible. Moreover, the number and variety of symptoms which poisons produce, many of which closely resemble those characteristic of natural disease and are easily mistaken for them, complicate and embarrass the examination. There are several diseases whose course and termination resemble the action of certain poisons. In short, of all crimes that of poisoning requires the most learning, acuteness, skill, and promptitude for its detection. The importance of the physician's part in the work is equalled only by its difficulty. In the capacity of medical jurist he needs a thorough knowledge of the physiological, therapeutical, and toxical actions of poisons and of the lesions they may cause. As legal chemist he needs that wide knowledge of the kinds of poisons and of their distinguishing characteristics, and that practical experience and skill in chemical analysis and manipulation, which will enable him not only to detect a poison with certainty if it exists, but also to avoid all risk of obtaining evidence of it, or of confounding things similar but innocent.

Classification of Poisons for Legal Uses.—Dr. Pugnet suggests ("Med. Leg. Papers," 2d Ser., rev. ed.) that the division of poisons into the organic and the inorganic, though acceptable to the chemist, is insufficient for the needs of the medical jurist. He suggests the following:—

- I. Corrosives.
  - *Strong Mineral Acids*: Sulphuric acid. Nitric acid. Muriatic acid.
  - *Vegetable Acids*: Oxalic acid.
  - *Alkalies*: Strong alkalies. Alkaline carbonates, etc.
- II. Simple Irritants: The above diluted. Lime. Zinc. Silver, etc.
- III. Specific Irritants: Arsenic. Mercury. Antimony. Phosphorus. Iodine.
- IV. Neurotics.
  - *Narcotics*: Opium and its active principles.
  - *Sedatives.*
    - *Cerebro-spinal*: Hyoscyamus. Belladonna. Stramonium. Cannabis Indica.
    - *Spinal*: Digitalis. Aconite. Prussic acid. Tobacco. Hemlock.
    - *Vaso-motor*: Hellebores.
    - *Anæsthetics*: Chloroform. Chloral. Bichloride of methyline. Ether. Nitrous oxide. Amylene.
  - *Convulsives*: Nux Vomica, Brucia, Strychnine.
- V. Asphyxiants: Noxious gases.
- VI. Abortives: Ergot. Savine, etc.

The corrosives destroy the tissues with which they come in contact by chemical action, and are characterized by causing intense pain with a burning. The simple irritants cause primarily irritation; secondarily, inflammation, which may prove fatal. The specific irritants act primarily as local irritants, but have a secondary specification. These are the poisons with which the physician is most frequently called to deal in this country. In acute cases they cause lesions of the alimentary canal; but in cases of slow poisoning these are wanting. Of the neurotics, Dr. Pugnet says that they have not as yet occupied a prominent place in toxicology, but the day is not distant when the practitioner may be called upon to investigate cases of criminal poisoning by means of them.

The above classification is the most complete which the writer has seen. Others which have received wide approval are those of Orfila, Taylor, and Tardieu (the leading features of which are given in 2 Wharton & Stillé's "Med. Jur.," 4th ed). What recommends it to the toxicologist is that the various poisons are classified according to their distinctive physiological action upon the living organism, and not upon their chemical organization and differences. Classifications by Christison and Foderé are also widely quoted.

Counsels and Cautions Relative to a Legal Inquiry.—The various works that discuss toxicology in its chemical and medical aspects contain numerous counsels and cautions to the practitioner as to the manner of carrying forward the scientific investigation necessary in cases of supposed poisoning. This paper will select and mention such as are particularly applicable where a suspicion of crime arises.

Remember that poisons may enter the system with fatal effect, not only by swallowing, but also by inhalation, by absorption through the skin, including the accessible mucous membranes, and by injection, subcutaneous or *per anum*. Swallowing is the mode best adapted for administering them with murderous intent, but in cases where the symptoms are obscure and not explainable by a suspicion of a poison swallowed, the medical jurisprudent will do well to consider the possibility that one or the other modes may have been employed.

In particular persons, substances ordinarily poisonous may be rendered inert, or those not ordinarily unwholesome may be rendered poisonous, by some idiosyncrasy of the individual, by a habit of taking them, or by a condition of disease.

A poisonous compound may, by possibility, be formed within the body by two medicines innocently prescribed or taken, either of which alone would have been innocuous.

An organ may, by possibility, become impregnated with a poison after death, either accidentally, as where it has been laid in a soil in which are poisonous elements, or where such elements are introduced in the process of em-

balming, or feloniously, as where an attempt is made to introduce a poison in order to give ground for charging an innocent person with murder. The presence of substances introduced after death is scientifically distinguishable, no doubt, from those taken in life; but the two may be confounded if the distinction is forgotten.

The narrative of the symptoms attending the last illness is of less service than is usually supposed in determining the criminal character of the case. Modern experience is that death cannot be safely attributed to poisoning from the symptoms alone; too many diseases resemble the action of poisons to allow of dispensing with an autopsy and a chemical examination, when poisoning is suspected. And still less light is thrown by the mere symptoms upon the question—fundamental in the legal aspects of the subject—whether the poison was taken accidentally or ignorantly, or was taken with suicidal purpose, or was administered with felonious intent; this question must be decided from the general attendant circumstances of the case.

The physician should never allow moral circumstances to prejudice his mind, neither should he neglect them. Indeed, he is the best judge concerning them. Let him ascertain whether an enmity exists between the sick person and anyone who attends or visits him; whether any poisonous substances have lately been purchased; whether these are still in the house; whether the alarming circumstances came on immediately after taking a drink or any other substance of an innocent nature; and particularly, in case of a sick person, let him ascertain whether anything has been given without the orders of the physician or by a person ignorant of drugs; and then he should draw a comparison between the symptoms present and those that ordinarily accompany the supposed disease.

He should carefully examine and preserve samples of every article of a suspicious nature, such as vials, boxes or papers containing powders, remains of food or drink, linen, sponges, cooking utensils, etc., in use about the patient; and he may (if assured of the support of the persons interested to promote justice) safely exercise a good deal of assumed authority in taking such precautions as against anybody who may object or oppose. Often a careful search of the premises and of the dead body will bring to light some article which, coupled with peculiar circumstances, warrants suspicion.

To decide between the relative probability of suicide and murder is a difficult question. The following facts are considered to indicate suicide: that the deceased had recently met with great losses or disappointments, or was suffering under disgrace, or under some form of insanity or delirium; that the mode of poisoning was cunningly devised to avoid a suspicion of suicide while yet the deceased held a life insurance policy; that he left any recent writing expressing his last wishes. If death has not occurred, the circumstance that the patient does not complain, but declines medical aid and remedies, confirms a suspicion of suicide. On the other hand, such suspicion is partially excluded when the circumstances favor the presumption that the deceased was in the enjoyment of a prosperous and happy life; when the drug employed is rare and procurable only with great difficulty, or is one which needs the co-operation of a second person for its administration, or is known to be productive of long and severe suffering. Considerations like these, and the results of a skilful toxicological investigation, in which the means afforded by anatomical and microscopic science, chemistry, and spectral analysis are useful to be employed, are more important in determining that the death is attributable to poison, and that this may probably have been criminally administered, than are the mere symptoms.

The examiners should observe perfect cleanliness at every step of their work; the organs removed from the cadaver for chemical examination should not be placed, for example, upon boards or in receptacles which have been cleaned with disinfecting solutions which may have had poisonous constituents, but should be placed in glass or porcelain lined dishes previously cleansed. The prudent and judicious advice given by Wharton and Stillé (2 "Med. Jur.," § 111) is that whenever, in a case involving a suspicion of murder, "a chemical analysis for poison is to be made of any of the organs, these organs should be placed by the physician himself in perfectly clean glass jars; glass preserve-jars with a glass or porcelain-lined cover are suitable for the purpose, and can always be obtained in the country or city. Each organ should be placed in a jar by itself—for instance the stomach in one jar, its contents in another, the intestines in another, contents of intestines in a fourth, the liver in a fifth, the kidneys in a sixth, the brain in a seventh, etc. The organs which should be saved for chemical analysis are, in order of their importance, as follows: stomach, contents of stomach, liver, intestines, contents of intestines, kidneys, brain, heart, spleen, and urine if there be any; in some cases, it is important to save portions of the muscular tissue, and in others a part of the lungs. In some cases it is wise for the physician making the examination to divide each of these substances into approximately two equal parts, each part to be kept in separate jars, one to be given to one chemist for preliminary analysis, and the other to be retained by the physician himself, in case it may be necessary to have the analysis confirmed by another chemist, as is usually the case in trials for murder by poison. These jars containing the organs should be closed and sealed by the physician himself, the seal to be stamped with a private stamp. They should then be locked up until they are to be delivered to the chemist. It is better that the organs be placed under double lock, one key to be taken by one person and the other by another, so that neither one alone has access to the organs; this is, of course, not necessary if one person possesses the key and another has possession of the stamp with which the seals have been stamped. When the jars are to be sent to a chemist, they should be sent by messenger, preferably by two messengers, since, in the event of the investigation resulting in a trial for murder, the identity of the organs cannot be lost by the death of the messenger. The organs should never be sent by express, since it is, in that case, impossible to preserve with absolute certainty the identity of the organs."

Sending the organs or their contents to the chemist is often not enough, especially where crime is suspected. Thus, the reason why no poisonous substance is found in the stomach may be that all which was not absorbed was vomited; therefore, all vomited matter which can be procured, including clothing, or carpet, or surface of floor which has received it, should have chemical examination. The vessel in which vomited matter has been contained will often furnish valuable evidence, since heavy mineral poisons fall to the bottom, adhere to the sides, or leave a sediment. The offender may have had the intelligence and opportunity to empty the basin, etc., but not have thought, or not have been able to attend to the dress or the floor.

Formerly it was the practice to confine the analysis to the stomach and its contents. Experience has, however, shown that most, if not all the viscera, including the bladder and urine, are required before anything like a satisfactory conclusion can be drawn as to the existence of poison.

The stomach, with its contents, should always be received by the analyst in its entire state, and not, as was formerly usual, sent to him slit, and the contents mixed in a jar with other fluids and organs—a practice which is highly objectionable, as it may lead to the ends of justice being defeated by the complication involved. A slight incision may suffice to inform those who perform the autopsy of the state of the organ and the nature of its contents, when it should be tied and handed to the analyst. If, in case of accident or dispute, a necessity arises to preserve a portion of the stomach and other organs, together with any fluids or solids, in bottles or otherwise, for further reference and confirmation, this may be done, but they should all be properly labelled and dated, and kept in a cool place.

Besides receiving the matter to be analyzed or examined, the analyst should be thoroughly informed upon

the history of the case, and the symptoms and effects, as a knowledge of these will aid his examination, enable him to avoid useless searches, and prevent his overlooking suspicious facts. He should even be informed of the exact time of the death, which is important in reference to the length of time usually taken for a fatal operation of the poison suspected; of the attitude of the body, etc., especially if there were any dying struggles; as certain poisons cause characteristic writhings or convulsions.

The analyst should never leave the vessel containing the suspected fluid in an exposed situation. He should keep it under lock and key, and, if interrupted in the course of the experiments, should restore it to such a place that he can positively affirm that no one could have meddled with it.

The notes of an autopsy, or chemical examination, should be promptly reduced to an orderly report; and greater care than is usually taken is desirable to avoid the use of medical or chemical terms, such as are not easily understood by judges and jurors.

When the chemist has completed his analysis, if he finds that the poisoning has been committed with an inorganic poison, such as arsenic, antimony, etc., he should bring the metal into court, and present it to the jury; and there should be a sufficient quantity of it in order to submit it to all the tests necessary for its identification. With the organic poisons, the legal chemist would find this almost an impossibility, as the organic poisons are much more active, and are fatal in smaller doses. Their presence can be proved by various tests which are reliable; but their very nature would tend to prevent their complete isolation in sufficient quantities for presentation to the jury. *Benjamin Vaughan Abbott.*

POISONOUS INSECTS. In the preparation of this article the author feels called upon, by way of premise, to state that the term "insects" is used in the larger, popular sense, and is, technically speaking, not a very good index to the article itself, which is intended to include those Arthropods which are known to be more or less poisonous, and to affect man and other animals, and not to include the vast number of minute, poisonous creatures which produce abnormal growths upon plants. In order to cover the ground as fully as possible, within the limits required by the editor, a systematic arrangement of the species is adopted, beginning with the lower, and, to avoid detailed descriptions, brief classificatory characters are given.

The question as to the relative virulence or innocuousness of insect poisons is one depending very much upon the susceptibility of the individual poisoned. The effect depends in great measure upon the health and constitution of the individual attacked, and may even depend upon other circumstances—as, for instance, whether the venom has been previously more or less fully expended or exhausted. With most poisonous insects, as with poisonous species among the higher animals, there is usually connected with the bite or sting a poisonous secretion, which may come from distinct poison-glands or from the ordinary salivary glands more or less modified. The secretions of these glands are elaborated by a successive series of epithelial cells that line the interior of these organs. The fluid contained within the cells forms the poisonous secretion. It stands to reason that when this is expended too frequently the fluid is diluted, and its property rendered less active. The poison in Arthropods has not yet been as fully studied as that of the venom of serpents by Dr. J. Weir Mitchell, and others, so that there is great room for careful study and experiment. There is reason to believe, however, that in the more venomous species, as the tarantulas or bird-spiders, and the more poisonous of the Hymenoptera, the nature of the poison is similar to that of snakes, since the consequences, as well as the antidotes, are somewhat similar. The poison in reptiles is an albumen compound, while in the less venomous Arthropods it is some form of acid, the general antidote being some non-poisonous base, like the alkalies—magnesia or lime and their carbonates, ammonia, etc. From the more intense poisons we have, in Arthropods, every gradation, and in the majority of cases the effect is simply corrosive. Some cases will be included in the following account, as, for instance, the effect of wormals and other larvæ, where there is reason to believe that the result is due purely to mechanical irritation, no poison being secreted, though the creatures are generally accounted poisonous in the popular mind. In all true stinging insects only the female has the power, the sting being, in fact, a modified ovipositor; and in the Diptera, which bite or lance with the mouth, it is the female alone which torments. In those insects which pierce by the beak (mostly among the Hemiptera), on the contrary, both sexes take part.

Class Arachnoidea.—Air breathing Arthropods, with head and thorax united into one solid piece, with mandibles and maxillæ, eight legs and legless abdomen. Members of this class vary greatly in the formation of their bodies. Head and thorax are almost always united in a short cephalo-thorax, but the abdomen is very different in the various orders.

Nearly all Arachnoidea are produced from eggs; a few mites and the scorpions form the exception. The newly hatched young possess mostly the form of the mature individuals. Some mites, however, have only six legs, others only four, when born; but in most instances the other legs appear later with the successive moults.

The great majority of the Arachnoidea feed upon animal matter; only a few subsist from vegetable substances. The larger and more highly organized forms kill their prey—chiefly insects—by means of peculiar organs, situated either on the anterior or the posterior end of their bodies; in most cases they have the power to secrete poison, which renders their bite or sting more effective.

Order Linguatulida.—Parasitic Arachnoidea, with a worm-like, transversely wrinkled body and two pairs of jointed hooks near the opening of the mouth, which possesses no mandibles. These animals were for a long time considered true intestinal worms. This worm-like appearance is produced by the very small cephalo-thorax, but chiefly by the enormous increase in length of their abdomen. A similar increase in length takes place in the well-known parasitic mite of the human nose, the *Demodex folliculorum* Linn.

Mature specimens of Linguatulida possess no mouth-organs whatever; the four chitinous, jointed hooks, that can be entirely withdrawn into pockets, are probably the claws of the last two pairs of legs, the two pairs of front legs of the larva having been lost during the moults. Eyes and organs for respiration and circulation of the blood are also lacking; a simple intestinal tube in the centre of the body opens in the posterior anus. Males and females differ greatly in size; the genital organs of the very small male are close to the mouth, those of the female at the posterior end of the body.

Sexual specimens of Linguatulida are found in the air-spaces of vertebrates and amphibia, and were first discovered by Chabert, in 1787, who named them *Tænia lanceolata*. Professor R. Leuckart has observed the transformations of *Pentastomum* tænioides*, which occurs in the nasal cavity of dogs, rarely of horses and goats. It is a white or yellowish animal, lancet-shaped, with a flat abdomen, rounded upper-side, and divided into about ninety segments; many stigmata occur along the sides of the abdomen, which measures in the males from eight to ten millimetres, in the female seventy to one hundred and thirty millimetres. The life-history of this animal has been studied by Zenker, Leuckart, Loudon, and others. Zenker discovered the frequent occurrence of this parasite in man.

The embryos, still enclosed in the eggs, find their way with the mucus of the infested animals to plants, and thence to the stomach of rabbits or man. Here they hatch and penetrate to other organs, but chiefly to the liver, where they occasion serious injury. If the host does not succumb, they encyst themselves, undergo sev-

* Pentastomum—five mouths, the four claws having been considered erroneously as mouths.

eral metamorphoses, and develop into a toothed Pentastomum (*Pentastomum denticulatum*). If they succeed in reaching the flesh of their usual host—the rabbit, the mouth of a dog—then they penetrate at once to the air-passages, where in the course of three months they assume their sexual form.

Dogs infested with this parasite sometimes become perfectly frantic and appear mad. Dr. Loudon reports the case of a man who suffered for seven years with constant bleeding of the nose; the removal of the parasite soon restored his health; he suffered also from the young parasites, which had found their way to his liver. The female parasite is said to deposit as many as five hundred thousand eggs. The bad habit of kissing dogs is again illustrated in the case of this parasitic mite. Dogs should never be allowed to eat the intestines of rabbits, of which they are very fond. Injections of benzine into the nasal

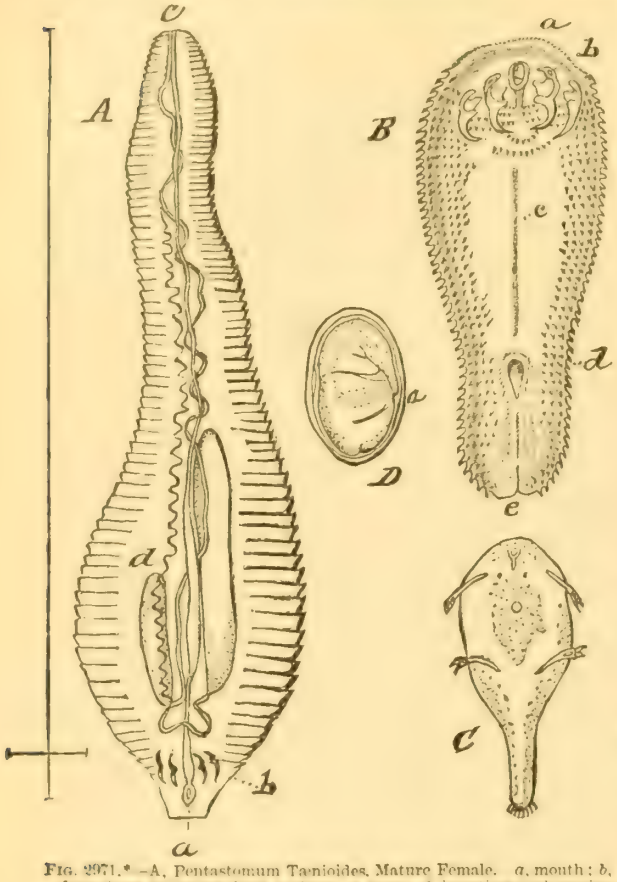

Fig. 2971.*—A, Pentastomum Tænioides, Mature Female. *a*, mouth; *b*, four claws projecting from pockets; *c*, anus; *d*, intestines and ovaries. B, Toothed Pentastomum—Pentastomum denticulatum; young. *a*, mouth; *b*, double claws; *c*, intestine; *d*, future genital opening; *e*, anus. C, larva of Pentastomum tænioides, showing the two pairs of legs, which are lost in older specimens. D, Egg with embryo. All greatly enlarged with the exception of A. (A and B after Zürn; C and D after Leuckart.)

cavities of infested dogs have been reported as curative; but prevention is preferable. Many similar species occur in various animals.

Order Acarina (Mites).—Arachnoidea with stout bodies, having the unjointed abdomen consolidated with head and thorax, with biting, sucking, or puncturing mouth-organs, breathing mostly by means of tracheæ.

Fam. *Dermatophili.*—*Demodex* (*Simonea*) *folliculorum* Sim. is found in the sebaceous crypts and hair-follicles of the nostrils of man, occasioning the well known comedones. The mite is distinguished by an elongated, worm-like, transversely wrinkled abdomen, by a suctorial beak, dagger-like mandibles with two palpi, and four pairs of very short, two-jointed legs, each armed with four claws. The abode of this microscopically small animal is usually filled above with a plug of fatty matter, which in time becomes discolored near the surface, forming the nasty "black heads." The number of mites found in each of the burrows is very variable, reaching sometimes as many as thirteen. Young and elongated six-legged; older, short, and eight-legged specimens, as well as eggs, are usually found together. Length of mature specimens, about 0.2 mm.

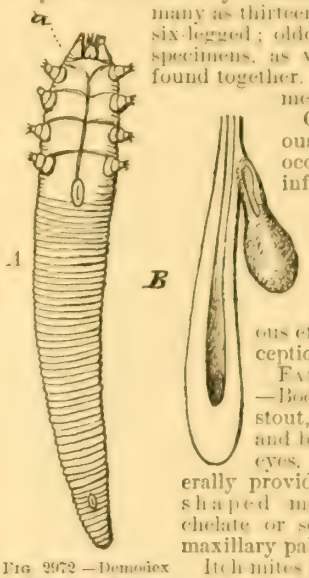

Fig. 2972.—Demodex (Simonea Folicenlorum. A, showing the mature mite: *a*, mandibles. B, showing the nate *mata*. Both greatly enlarged. (Original.)

Other species occur in various animals, and frequently occasion serious injury to the infested organs.

The two mites Pentastomum and Demodex are the lowest forms of the Arachnoidea, but must be placed in the two respective orders. Their poisonous effects are slight, but in exceptional cases quite evident.

Fam. *Sarcoptida* (*Itch-mites*).—Body microscopically small, stout, soft, with chitinous rods and bands to support legs. No eyes. Skin striated. Tarsi generally provided with suckers. Cone-shaped mouth-parts, consisting of chelate or scissor-like mandibles and maxillary palpi.

Itch-mites have a flat body, more or less circular in outline. The legs extend but a short distance beyond the body; they are supported by chitinous appendages, which look like the garters in the familiar picture of an Italian brigand. In Fig. 2973 the striated surface of the skin is shown, as well as the banded legs and the suckers. The chelate nippers are well adapted to mining galleries in the skin of an infested animal. Like many other animals that lead a burrowing or endophitous life, they need no eyes, and have consequently lost them.

There are numerous species of mites which belong to this family and the genus *Sarcoptes*. The most important one, as affecting man himself, is the *Sarcoptes hominis* Raspail, or the *Acarus scabiei* Fabr.*

The itch-mite seems to have been known to Aristotle. The first mention of it occurs in the "Physica St. Hildagardis;" the authoress was living in the twelfth century, in a convent upon the Rupertsberg, near Bingen. The mite is frequently mentioned and described, by some as the cause of the itch, by others as the effect of the disease, while still others have denied its very existence. During the first years of this century the French Academy of Sciences offered a prize of 6,000 francs for the rediscovery of this mite, which had already been closely observed and figured by Wichman in 1780. In the year 1812 a meeting of naturalists and physicians at Paris was greatly mystified and tricked by Dr. Gales, who not only substituted cheese-mites for the itch-mites, and pocketed the prize and medals, but had the audacity

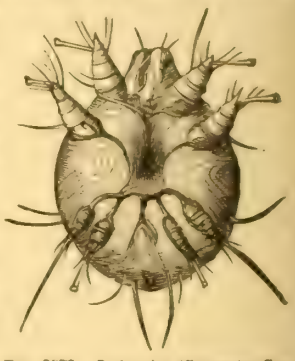

Fig. 2973.—Itch-mite (Sarcoptes Scabiei. (After Jeffries.)

* The illustrations are duly credited in the explanations, the few original figures being drawn and engraved especially for this paper.

* It is doubtful whether Fabricius described the real itch-mite of man or some allied species.

to publish descriptions of them. Many naturalists in vain searched for the mite, mislead by Gales's book, until in 1829 Lugol offered a second prize to rediscover it. A student of medicine, Renucci, at last, in 1834, showed in Paris a method by which it could be found; he utilized a method used in Corsica and elsewhere, to kill the mites by removing them with a needle. The existence of the itch-mite was thus demonstrated, but whether it was the cause or effect of the disease was a mooted question. It is now well known that these mites are the cause of the disease, which can be produced at will by introducing the mite, and which can as readily be cured by proper means known to every physician.

When examined with the naked eye, the mite looks white and shining, and was aptly described by Bonomo, one of its first observers, as like a little bladder of water; when seen running, however, upon the surface of a plate of glass, it may be perceived that its anterior margin presents a dusky tint of color, and the examination of this part of the creature with the microscope brings into

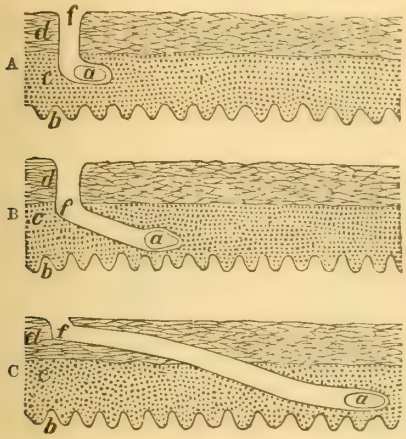

Fig. 2974.—Acarian Furrows. *a*, Position of mite. A, the mite has gone down beneath the epidermis. B, the mite has commenced to dig a longitudinal burrow, and the place (*f*) where it was in A, has by the growth of cells come up nearer to the surface. C, the point (*f*) has come up to the surface, while the mite has gone along farther with its burrow. (After Jeffries.)

view a head not unlike that of a tortoise, and a pair of large and strong legs on each side of the head.

The most apparent difference between the male and the female is the smaller size of the former and the different formation of the two posterior pairs of legs. In the male the third pair are terminated by a long bristle, and the fourth by a pediculated sucker, whereas in the female both third and fourth pairs are terminated by a long bristle. On the under side of the male, moreover, there is a complicated series of chitinous bands, which are not present in the female. When newly hatched, the young Sarcoptes has but three pairs of legs, and the hind pair terminate in a long bristle.

The mite lives in the human skin, making little tunnels therein. The female, as she works her way, lays her eggs behind her, to the number of about fifty, and they are said to hatch in from three to six days. If O. Fuerstenberg's illustration in "Die Krätzmilben des Menschen und der Thiere," Leipzig, 1861, may be depended on, which shows a considerable number of eggshells, dropped irregularly all along the burrow, and only one unhatched, close to the mite, we should imagine that the shorter period was the most probable.

The mite changes its skin four times before it attains maturity, and a few days after the last of these moults it obtains the additional posterior pair of legs. This pest was formerly much more common than now. Soap and water, and cleanly habits, have rendered it comparatively scarce; but whenever numerous bodies of men are crowded together, without time and opportunity to attend to their personal cleanliness, it reappears and rapidly spreads. Armies suffer much from this and other vermin. "The army itch" "the seven years' itch," "the Jackson itch" are terms used for the common itch flourishing under specially favorable circumstances.

The great English authority on skin diseases, Dr. Erasmus Wilson, gives the following as the indications of an attack by this insect, viz.: firstly, a peculiar scaliness and undermined state of the epidermis, which is not met with in other cutaneous affections; secondly, the presence of conical vesicles with acuminate and transparent points; thirdly and principally, the presence of the mite itself, which may be extracted from its retreat beneath the loosened epidermis with the point of any sharp instrument. The diseases which he mentions as apt to be confounded with it are eczema, prurigo, lichen, impetigo, and ecthyma.

When one of the early vesicles of the itch is examined with attention, a minute spot or streak may be observed upon some one point of its surface. This is the aperture originally made by the insect on its first entrance within the epidermis, and from this spot or streak a whitish fluted line may be traced, either in a straight or curved direction, into the neighboring epidermis.

The whitish line is the cuniculus, or burrow, of the acarus; and the fluted or dotted appearance is due to the eggs, the white dots indicating the points where the eggs lie. The burrow necessarily varies in length, being sometimes as much as five or six lines in extent; and at its termination, under a slight elevation of the skin, the little inhabitant lies concealed. The mite may be easily distinguished by the experienced eye as a small dark point at the end of the burrow, and if a thin capsule of skin be raised in this situation with the point of a needle the little creature is brought to view.

The proximate cause of the appearance of itch is the presence of this mite, which is transferred from infected to non-infected persons by actual contact. In some instances it may be conveyed to the person in its adult stage; while in others ova or embryos suspended in the fluid of the vesicles may be the mode of transmission. Certain it is that the application of one of the mites to the skin of a sound person will give rise to the disease. The precise mode of its transmission, however, was for a time a puzzle. Its contagious nature could not be disputed, but it was remarked with surprise that infection among doctors and hospital-attendants was comparatively rare. Dr. Aube set himself to find out the cause of this; and he learned, from a great number of inquiries of patients as to the manner in which they had contracted the disease, that it was almost always by having slept in the same bed with an infected person. He found that the number of those who had so contracted it was to those who had acquired it by manual contact as 100 to 5.

Dr. Aube inferred from this that the mite was a nocturnal animal, and his other observations and an experiment made upon himself confirmed this view. The animal hides under the skin during the day, but walks about at night, perhaps excited by the greater warmth of the body in bed, and pricks the skin in various places. This explains the rarity of contagion during the day, and the small number of burrows that may be remarked on the skin even when there are a great number of pustules; and also why the violent itching only occurs during the night. In confirmation of what we have said, we may quote the statement of Dr. B. Joy Jeffries ("American Entomologist," ii., 118), that in the great hospital at Vienna 1,500 cases are treated yearly, and no attempt at disinfecting the clothing is found necessary. The underclothing should be washed thoroughly, but outside garments, contrary to the general opinion, do not need disinfection.

Treatment for getting rid of the parasite is very simple. Sulphur is the specific. It may be mixed in soap, like the Gishurst Compound and various other similar preparations, or it may be administered in an ointment. By bathing and steeping the parts affected in hot water or vapor, and then rubbing off the skin as much as possible, the Sarcoptes is laid sufficiently bare to allow the sulphur to act through the skin upon it. But although

the mite itself is thus easily killed, the eggs are not, and this explains why one application is rarely sufficient; but after a pause of a day or two, during which the surviving eggs may be hatched, the process may be repeated. The newly hatched insects will thus be killed before they have had time to begin to lay eggs, and as soon as the old crop of eggs is exhausted the cure is complete.

It is not alone on man that this species establishes itself. It has been found on the lion, on the dog, the llama, the sheep, the ox, the horse, and the hog; and although it is possible that some of the observations on which this statement is made are erroneous, and that some allied species peculiar to the animals in question may have been mistaken for the *S. scabiei*, still there is no reason to doubt that as a species it is very widely distributed and found on a great number of different mammals. We hear of old mangy lions in a wild state, but it is only in captivity that they are really attacked by the itch, which no doubt they owe to the dirty attendants who wait upon them. They succumb rapidly to its attacks, dying in a few months, and becoming miserable objects before they die. The head is the part chiefly attacked. It becomes covered with a thick crust, the nostrils closed, the skin swollen into hard folds. In speculating upon the cause of the itching sensation and inflammatory symptoms of the skin in attacks of the Sarcoptides, the first and most natural supposition is that they are caused by the incessant, minute nibbling going on just at the termination of the smallest ramifications of the sentient nerves supplying the skin. Undoubtedly a constant gnawing of this kind must not only produce irritation, but irritation of a kind quite different from any less continuous and minute shaving. But then we have different symptoms produced by different species—the scurfy, inflamed surface of the *S. scabiei;* the coarse, leprous crust of the *S. scabiei-crustosæ;* the deep ulcers of *Glyciphagus hippodos;* and so on. While it is possible that there may be some difference in the kind and degree of mechanical irritation to produce such different results, yet the presumption is that there is some special poisonous or irritant virus connected with the bite of the different species, and this hypothesis accounts for the variation in the phenomena observed in each.

Several other species of itch-mites infest man, but they are fortunately much more rare. The *Sarcoptes scabiei-crustosæ* (the Norwegian itch-mite) was first noticed in 1848. The mite is much smaller and darker, and produces tubercles covered with thick, brownish crusts.

The complaint, as described by M. Boeck in a treatise on the "Spedalskhed," in 1848, is chiefly seated in the hands and forearms, and is characterized by crusts of a dirty-yellow color, of considerable thickness, especially on the hands, where they form a stratum that reaches, and even exceeds, half an inch in thickness, and traversed by broad and deep cracks, which correspond more or less with the articular folds. The bottom of these cracks is moist and whitish; the smell is repellant, and the patient suffers from an incessant and extreme itching. The mites are found in the crust, but not in the substance of the skin.

Fam. *Ixodidæ* (Ticks).—Large, mostly blood-sucking mites, with a tough, leathery tegument; large, saw-toothed mandibles, with from two to four terminal hooks, and with a large spatulate, dentate "glossoide" of the maxillæ, forming a beak. The slender legs end in two claws. Two ocelli frequently present.

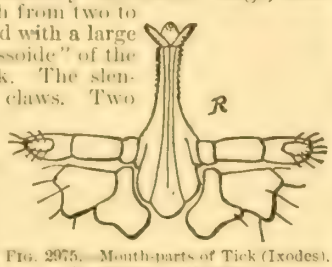

Fig. 2975.—Mouth-parts of Tick (Ixodes). R, rostrum. (Original.)

These gigantic mites, possessing a tough, smooth, leathery skin, frequently highly ornamented with bright colors and markings, are well known to everyone who has rambled in the country. The skin of the female is capable of much extension. The rostrum, or beak, adapted to sucking, is pushed into the skin of the host, and cannot readily be withdrawn, if once inserted, on account of the recurved hooks. The sucking apparatus is situated on each side of the mandibles, where two tubes perform this office. The slender legs, with two claws, possess in the young and six-legged tick a distinct membranous foot-pad, which acts as a sucker. A small shield behind the head is also an important characteristic of these mites. Their young have head- and mouth-parts much larger in proportion to the rest of the body than the adults; the tripartite division of the body is also very distinct, and the thorax is quite distinct from the head and abdomen.

Ticks of various species are common in our woods, preferring the vicinity of roads or houses. From the plants, upon which they patiently wait for a passing host, they find their way to the skin of animals and man, where they fasten themselves, insert their rostrum, and suck the blood. The females distend their large abdomen to such an extent that they grow to the size of a bean; the legs become useless, and the tick is solely kept in position by the inserted rostrum. The abdomen of the male is not capable of distention like that of the female. The young or "seed ticks" cluster upon plants, and from these often crowd upon the exposed parts of man, especially of children, causing intense irritation.

Packard ("Guide to Study of Insects," etc., p. 662) says: "Travellers in the tropics speak of the intolerable torment occasioned by wood-ticks, Ixodes, which, occurring ordinarily on shrubs and trees, attach themselves to all sorts of reptiles, beasts, and cattle, and even to man himself as he passes by within their reach. Sometimes cases fall within the practice of the physician, who is called to remove the tick, which is found sometimes literally buried under the skin. Mr. J. Stauffer writes me that on June 23d the daughter of Abraham Jackson (colored), playing among the leaves in a wood, near Springville, Lancaster County, Pa., on her return home complained of pain in the arm. No attention was paid to it till the next day, when a raised tumor was noticed, a small portion protruding through the skin, apparently like a splinter of wood. The child was taken to a physician, who applied the forceps, and after considerable pain to the child, and labor to himself, extracted a species of Ixodes, nearly one-quarter of an inch long, of an oval form, and brown, mahogany color, with a metallic spot, like silver bronze, centrally situated on the dorsal region." This tick proved, from Mr. Stauffer's figures, to be *Ixodes unipuncta* Pack.

The genus *Argas*, by some placed in a separate family, the *Gasmasidæ*, subfamily *Argasidæ*, is distinguished by

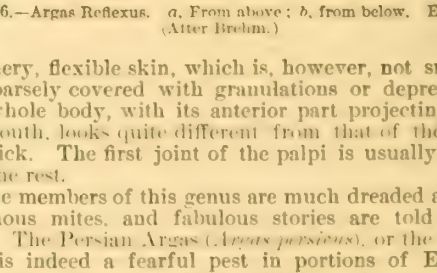

Fig. 2976.—Argas Reflexus. *a*, From above; *b*, from below. Enlarged. (After Brehm.)

a leathery, flexible skin, which is, however, not smooth, but coarsely covered with granulations or depressions. The whole body, with its anterior part projecting over the mouth, looks quite different from that of the common tick. The first joint of the palpi is usually larger than the rest.

Some members of this genus are much dreaded as very venomous mites, and fabulous stories are told about them. The Persian Argas (*Argas persicus*), or the "Malleh," is indeed a fearful pest in portions of Europe, Asia, and Africa, and closely allied species occur also

in this country. They inhabit houses, like our common bed-bug, and move about actively during the night, filling themselves with blood, and leaving a very painful wound. They are sometimes so numerous as to force the inhabitants to leave their villages.

Another species, the *Argas reflexus*, is better known. It is usually found in houses where pigeons are kept. It prefers the blood of the young birds, but is very prone to attack man as well. Dr. Boschul put one of these animals in the hollow of his hand; it commenced to bite and drew forth blood for about twenty-seven minutes, and grew during this time to the size of a small bean. The bite appears like a small red dot, and produces violent itching, not so much at the point bitten, but along the veins. Small children bitten by them have symptoms of fever, lasting frequently for a whole week. Like bed-bugs, they never attack during the day. A room lighted by a lamp is a sure preventive of the bites of both.

Fig. 2977.—Trombidium Muscarum. Greatly enlarged. (After Riley.)

Fam. *Trombidiidæ* (Harvest-mites, Red Mites, Jiggers).—Mites distinguished by their bright colors and hairy bodies. Their palpi have generally the second joint longest, while the last bears an appendage of peculiar form that can serve as finger and thumb; eyes present. The six-legged larvæ are parasitic upon insects and spiders, but they frequently torment animals and man as well, producing sores of various kinds.

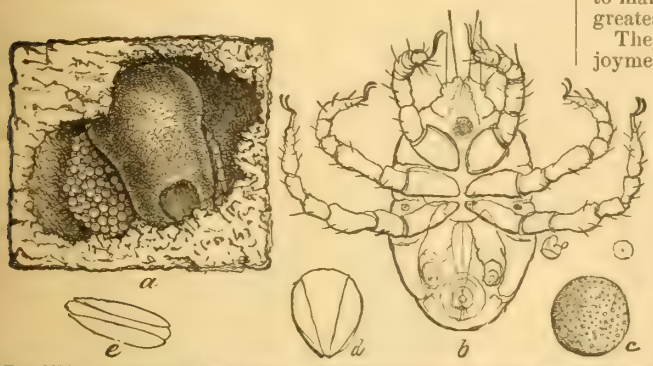

Fig. 2978.—Trombidium Locustarum. *a*, Female with her batch of eggs (after Emerton); *b*, newly hatched larva—natural size indicated by the dot within the circle; *c*, egg; *d*, *e*, vacated egg-shells. (After Riley.)

Types of this family are the red mites of our fields, the troublesome red spiders of our hot-houses, and the harvest-mites or jiggers of the meadows.

The transformations of some of these red mites were described and illustrated by us in the "First Annual Report of the United States Entomological Commission," 1877 (see also *American Naturalist*, March, 1878), where it is shown that the locust-mite (*Trombidium locustarum* Riley) is very beneficial, in the larva or Astoma state, in checking the increase of the Rocky Mountain locust (*Caloptenus spretus*). The small red parasite, which is frequently seen attached to the common house-fly, is the young of another red mite (*Trombidium muscarum* Riley). But the young of other species are not so useful to man, and the harvest-mites or jiggers are one of his greatest annoyances in the Central and Southern States.

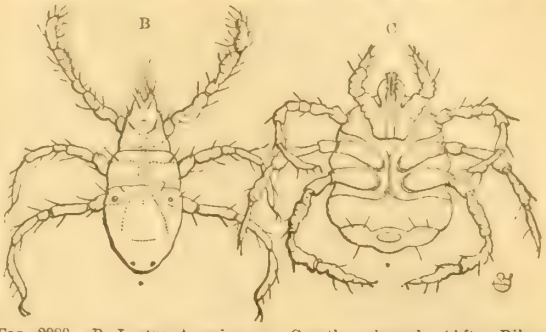

Fig. 2980.—B, Leptus Americanus. Greatly enlarged. (After Riley.) C, Leptus irritans. Greatly enlarged. (After Riley.) (In B and C the dots underneath indicate the natural size.)

They form one of the most serious obstacles to the enjoyment of rural rambles in summer-time.

The accompanying illustrations will show the transformations of the above-named species; and while those which torment man and the higher animals in this country have not yet been studied through their transformations, they will undoubtedly prove to belong to some species of Trombidium or allied eight-legged mite.

The two mites described below cause great annoyance, from harvest-time till into October, to people who frequent the rank herbage and grass in our forest-openings or along our rivers. Both of them are six-legged, reddish, microscopic species, and both of them are popularly termed in the United States "jiggers." This term is evidently a corruption of "chigoe," the name universally applied to the more dangerous *Sarcopsylla penetrans* L., which will be described later, and the term "harvest-mites" is preferable. Allied species are called "harvest-bugs" in England. We quote the following from an article which we communicated to *Colman's Rural World*, St. Louis, for June 21, 1876:

"*The American Harvest-mite* (*Leptus Americanus* Riley).—This species is barely visible to the naked eye, moves readily, and is found more frequently upon children than upon adults. It lives mostly upon the scalp and under the armpits, but is frequently found on the other parts of the body. It does not bury itself in the flesh, but simply insinuates the anterior part of its body just under the skin, thereby causing intense irritation, followed by a little red pimple. As with our common ticks, the irritation lasts only while the animal is securing itself, and its presence would afterward scarcely be noticed but for the pimple which results.

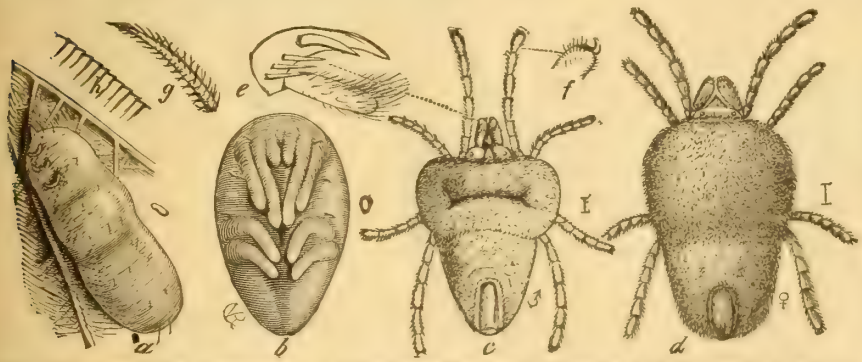

Fig. 2979.—Trombidium Locustarum. *a*, Mature larva when about to leave the wing of a locust; *b*, pupa; *c*, male adult when just from the pupa; *d*, female—the natural sizes indicated to the right; *e*, pupal claw and thumb; *f*, pedal claws; *g*, one of the barbed hairs; *h*, the striations on the larval skin. (After Riley.)

"*The Irritating Harvest-mite* (*Leptus irritans* Riley).—This is the most troublesome and perhaps best known of the two, causing intense irritation and swelling on all parts of the body, but more especially around the legs and ankles. Woe betide the person who, after bathing

in the Mississippi, or anywhere in this latitude, is lured to some green dressing spot of grass or weeds. He may for the time consider himself fortunate in getting rid of mud and dirt, but he will afterward find, to his sorrow, that he got hold of something far more tenacious in these microscopic harvest-mites. If he has obtained a good supply of them he will in a few hours begin to suffer from severe itching, and for the next two or three days he will be likely to scratch until his limbs are sore.

"With the strong mandibles and the elbowed maxillæ, which act like arms, this mite is able to bury itself completely in the flesh, thereby causing a red swelling with a pale, pustulous centre, containing watery matter. If, in scratching, he is fortunate enough to remove the mite before it enters, the part soon heals. But otherwise the irritation lasts for two, three, or four days, the pustulous centre reappearing as often as it is broken.

"The animal itself, on account of its minute size, is seldom seen, and the uninitiated, when first troubled with it, are often alarmed at the symptoms, and at a loss to account for them. Fortunately, these little plagues never attach themselves to persons in such immense numbers as do sometimes young or so-called "seed" ticks; but I have known cases where, what with irritation and consequent scratching, the flesh has the appearance of being covered with ulcers; and in some localities where these pests most abound sulphur is often sprinkled, during "jigger" season, in foot gear, as a protection.

"Sulphur ointment is the best remedy against the effects of either of these mites, though, when that cannot be obtained, saleratus-water or salt water will probably allay the irritation. Whether anything better than the sulphur can be used as a preventive I have no knowledge, and shall be glad to learn from those who have had experience. Any oily substance will act as a preventive, and, while kerosene is too offensive, sweet-oil might be tried. I would also recommend for trial alum-water, made by dissolving the alum in hot water, at the rate of an ounce or two to the quart.

"The normal food of either of these mites must, apparently, consist of the juices of plants, and the love of blood proves ruinous to those individuals which get a chance to indulge it. For, unlike the true chigoe, the female of which deposits eggs in the wound she makes, these harvest-mites have no object of that kind, and when not killed at the hands of those they torment they soon die—victims to their sanguinary appetite."

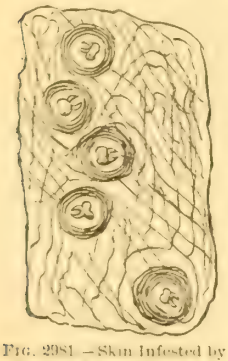

Fig. 2981.—Skin Infested by Leptus Autumnalis, showing the Imbedded Heads after Removal of Mites. Enlarged. (Original.)

The harvest-bug of Europe (*Leptus autumnalis*, or, according to Murray, *Tetranychus autumnalis*) is very similar to our species. It is sometimes so numerous that crops of currants and other berries have been abandoned. These mites seem to be able to penetrate stockings and drawers, and other thin clothing, for though generally most numerous and annoying about the legs, they are found all over the body. Cats and dogs, from their prowling habits in field and garden, suffer greatly. They scratch and nip their skin with their teeth, so much so that they are sometimes supposed to be suffering from the itch, when it is only from a daily re-enforcement of these mites.

Kirby and Spence mention a similar insect which occurs in Brazil, abounding in the rainy season, particularly during the gleams of sunshine or fine days that intervene, as small as a point, and moving very fast. These animals, they say, get upon the linen and cover it in a moment; afterward they insinuate themselves into the skin, and occasion a most intolerable itching. They are with difficulty extracted, and leave behind them large livid tumors, which subside in a day or two. An insect very tormenting to the wood cutters and settlers on the Mosquito Shore and Bay of Honduras, and called by them the "doctor," is thought to be synonymous with this. They add, on authority which they give, that more serious consequences have been known to follow the bite of another mite, related to the above, if not the same species, common in Martinique, and called there the *bête rouge*. When the English soldiers in camp were attacked by these creatures, dangerous ulcers succeeded the symptoms just mentioned, which in several instances became so bad that the limb affected had to be amputated.

Order Araneidæ (Spiders).—Body consisting of two parts, cephalo-thorax and abdomen, both undivided and connected by a slender pedicle. Mandibles two-jointed, second joint like a claw and movable against the first, either vertically or in a horizontal direction; they contain a poison-gland, which opens by a minute orifice near the apex of the claw. Maxillæ with a prominent leg-like palpus, bearing in the male the accessory genital organs. Labial palpi resemble the legs in form and function. Labium between the maxillæ immovable. Eyes simple, from six to eight. Abdomen provided at apex with four or six spinnerets. Respiration through lungs.

Like most animals which subsist on others, the voracity of spiders is extreme, and they devour not alone all sorts of insects, but also each other. The males are usually very much smaller than the females, and their courtship is by no means unattended with danger, the love of the female being at times truly devouring.

I. *Tetrapneumones.*—Large and powerful spiders, with four lungs, and mostly with four spinnerets.

Fam. *Theraphosoidæa* (Bird-spiders, American Tarantulas).—Large, hairy spiders, with four lungs, and

Fig. 2982.—Bird-spider (Mygale Hentzii). (From *American Entomologist.*)

generally as many spinnerets, of which two are very small.

This family is distinguished by very large, hard, and polished fangs, which move vertically, and can thus be used to pin down their prey. In Brazil they are frequently set in gold and used as toothpicks, possessing, as claimed by the superstitious people, the faculty of keeping away the toothache.

Bird-spiders are unpleasantly numerous in tropical and some sub-tropical countries, and many species are found in the southwestern part of the United States, where they are feared because of their poisonous bites. They are nocturnal in their habits, usually hiding during the day in self-made, long, silken tubes, in cracks of the ground, under palm-leaf thatched roofs, and in similar places. They spin no webs to entrap their prey, but either lie in ambush waiting for a victim, or search for it outside, catching it like hunting spiders, by powerful leaps. Insects, and particularly other spiders, form their staple food, but Mr. Otto Lugger, who kept some in captivity, has fed them also with young mice, frogs, and even young snakes. In shedding their skin they lie motionless upon the back, as if dead, until the old skin suddenly breaks in a longitudinal slit between the legs.

The bite of these spiders is quite painful, but not by any means as dangerous as claimed; it produces a violent inflammation of short duration. Scars made by such bites are quite lasting, however, looking like those so frequently made during dissections.

Aname (*Mygale*) *Hentzii*, a large bird-spider or tarantula not infrequently found even in the Eastern States, has been chosen to illustrate these dangerous-looking animals. *Aname Rileyi* Marx is its California representative, and reputed still more venomous.

II. *Dipneumones.*—With two lungs and six spinnerets.

Fam. *Lycosidæ* (Wolf-spiders).—These rather large spiders are distinguished by a long, oval, elevated cephalothorax, narrowing anteriorly, and eight eyes usually arranged in three rows. Their long and strong legs enable them to chase and catch their prey; during the day they usually hide under stones and chips in silken nests. The females protect their eggs and carry them about, and take care of their young for some time after being hatched.

The most famed and defamed of all spiders is the *Tarentula fasciventris*, which was supposed to cause the dis-

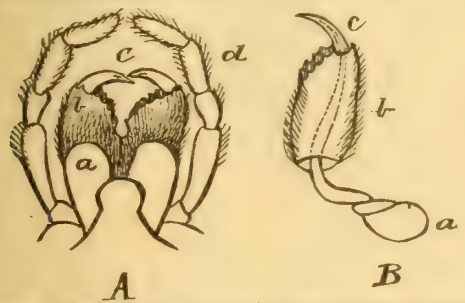

Fig. 2983.—A, Mouth-parts of Genuine Tarantula (Tarentula Fasciventris); *a*, palpi; *b*, mandibles; *c*, fang. B, Fang and poison-gland; *a*, twisted poison-gland; *b*, mandibles; *c*, fang with outlet for poison. (From the Gartenlaube.)

ease tarantismus or tarantula dance. The name Tarantula is derived from the Italian name Tarantola, which is a name for a poisonous spider (or solofizzi) common in the vicinity of Taranto, and whose bite was said to produce the most peculiar symptoms. Aldovrandi described very minutely the effects of the bite of a tarantula and the cure. According to his ideas, there is no human disease which cannot be produced by it; those bitten (tarantulati) sing continuously, cry, laugh, or weep; some always sleep, others always wake; some perspire or dance, suffer palpitation of the heart; some cannot force themselves to look at black or blue colors, while red or green is pleasant to them. To cure the tarantulati the tunes of two dances were played, the pastorale and the tarantola. These induced the bitten person to dance until he fainted, when he would sleep and rest till cured.

Generally speaking, the bite of a spider is harmless to man, although most spiders possess organs to secrete poison. The larger the spider, the greater the danger; however, the effect of the bite varies with conditions or the season of the year.

The poisonous secretion is an oily, clear fluid, with acid reaction and a bitter taste. The bite of a tarantula or of a malmignatte kills insects and birds; rabbits are also frequently killed by it. If spiders bite each other, both die after a few moments.

Fig. 2983 shows the poison-fang and gland of the true tarantula of Italy.

The malmignatte (*Lactrodectus malmignatus*) is frequently found in Italy, Corsica, and the Antilles. This spider forms an irregular web upon the ground to catch her prey and hides in a small silken cell in the vicinity. The poison-glands are large, but the fangs are small. This spider appeared in 1830 in large numbers in some regions of Spain, and created widespread fear on account of the poisonous effects of the bite. In 1833 it appeared again, and farmers hardly dared to leave their houses. During the harvest many people were dangerously bitten.

Fig. 2984.—Wolf-spider (Phydippus Tripunctatus). (Original.)

We have had little opportunity to observe the effects of spider-bites. The effect produced by an American species of the family Attoidæ (the *Phydippus tripunctatus* L.), as witnessed by one of our assistants, Mr. O. Lugger, in his own family, was in the nature of a little swelling of the skin, accompanied by great pain, itching, and inflammation. Chilliness and fever succeed each other in rapid succession, and convulsions sometimes take place in children and weak persons. The pain does not cease for several days, and only after free perspiration.

Order Pedipalpi (Scorpion-spiders).—Of large size; elongate and prominent maxillary palpi; first pair of legs very long, slender, and twelve-jointed, resembling antennæ, and not used, as in the true spiders, for locomotion. The eleven- to twelve-jointed abdomen is separated from the thorax by a marked constriction, with or without a tail—which, if present, is without sting.

The genus *Phrynus* Oliv. has the general aspect of a

Fig. 2985.—Phrynus Lunatus. (After Brockhaus.)

spider; the large maxillary palpi are armed with thorns and end in a hand-like organ with one movable finger. The mandibles are free, and probably contain glands to secrete poison, since the bite of these animals is greatly dreaded, though its effect is doubtless exaggerated. Abdomen flat, rather short, eleven-jointed, without a tail. Phrynus produces living young, and inhabits the warmer portions of the globe. A number of species occur in our southern and southwestern regions.

The genus *Thelyphonus* Latr. (Whip-tail, Nigger Killer, Mule Killer, Grampus, etc.) looks more like a scorpion. The maxillary palpi are shorter but stouter, and look like the claws of a cray fish. The last three segments of the abdomen are formed into a short tube the end of which is continued in a long, jointed, bristle-like tail. The animals possess twelve eyes, and breathe through air-sacs, which open in slits near the posterior margin of the second and third abdominal segments. Although they have a dangerous look, and are generally dreaded in regions where they occur, as in Florida and Texas, they seem to be harmless. Dr Geo. Marx, who published some notes upon these animals in *Entomological American* for May, 1886, says no poison-glands exist, since no orifice in the terminal mandibular claw could be found by him, such as exist in all other Arachnidæ which possess poison-glands in their mandibles. The odor, which some emit as a means of defence, is very penetrating and acidulous, and consequently Thelyphonus is vulgarly known by the inhabitants of some of the West Indian islands as the "Vinegar-maker" or "Vinaigrier."

Order Scorpionidæ (Scorpions).—Distinguished by immense forceps-like maxillæ, seven-jointed præ-abdomen, six-jointed, tail-like post-abdomen, with a venomous sting at the end, in which are lodged two poison bags. Two large ocelli placed close together in the middle of the cephalo-thorax, and smaller lateral ocelli distributed along its anterior margin. Respiration by means of four pairs of lungs.

Scorpions resemble our cray-fishes, possessing like them immense claws and a rather hard chitinous covering. Their legs are strong, and end in double claws. In their interior organization they are the highest developed of all arachnoideæ. They produce living young. Some reach a very large size and are able to endanger even the life of man. They are dangerous in proportion to their size, their age, and the state of irritation they may be in. Temperature also influences the venom. The wounds inflicted even by the largest species rarely prove fatal.

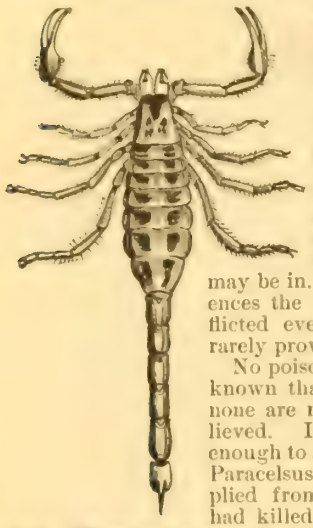

Fig. 2986.—Scorpion (Buthus Carolinianus Beauvois). (From *American Entomologist.*)

No poisonous arthropod is better known than the scorpion, and about none are more fables told and believed. Its forbidding aspect is enough to account for many of these. Paracelsus claimed that they multiplied from rotting scorpions which had killed themselves for this purpose, a belief evidently based upon the story that scorpions surrounded by glowing embers would kill themselves. Recent experiments would indicate that even this story is but fable. Scorpions may be provoked to strike and wound themselves or each other, but they are incapable of causing any toxic action upon themselves or upon other scorpions. According to Kirby and Spence, the only means of saving the lives of the English soldiers who were stung by them in Egypt was amputation, and they add that one species was said to occasion madness. There is no doubt that the sting of certain kinds common in South America causes fever, numbness in various parts of the body, tumors on the tongue, and dimness of sight, which symptoms last from twenty-four to forty-eight hours. Our common southern species, the *Buthus carolinianus*, which ranges from the Southern Atlantic States, through Texas, northward into Southern Kansas, inflicts also a very severe sting, which hurts for many hours.

The sting is not barbed, but its point is perforated, and it wounds simply by penetrating the skin and conveying poison into the wound through two orifices from a poison-bag. The poison is sometimes as white as milk.

Scorpions are common in tropical and sub-tropical parts of the world; they leave their retreats at dusk, running with their tail raised over their back, pointing forward. Their food consists mainly of spiders and large insects, which they grab with their claws, and, after scrutinizing, kill with their sting. During the day they hide under stones, in rotten wood, and in dark places. They are very fond of warmth, and frequently enter houses, and hide in beds clothing, shoes, etc., so that travellers in the tropics always run the risk of being stung by them. Liquid ammonia, even the ashes of tobacco, moderate the pain very quickly, and a small dose of ipecacuanha will overcome the faintness. The effect of the sting upon a person diminishes in virulence with repetition, and may become innocuous.

Order Solifugæ (Galeodes).—Spider-like animals, having head and thorax separated, with a long, segmented abdomen, scissor-shaped mandibles, and leg-like maxillary palpi; they breathe through tracheæ, and not by pulmonary sacs.

These large, hairy, and spider-like animals, reaching sometimes a length of two inches, are at once distinguished from true spiders by the segmented, elongated abdomen. They resemble, in the division of their body, true hexapod insects, because their cephalo-thorax is divided in two parts, of which the anterior part may be compared with the head, and the posterior three-jointed part with the thorax of insects. The cylindrical abdomen, formed by nine or ten segments, is strongly separated from the cephalo-thorax. The mouth organs consist of very large mandibles, ending in a large vertical pair of scissors, of which the lower arm moves in a vertical direction against the upper arm, which is also movable. The maxillary palpi serve as legs, but lack the claws, which are found only in the three pairs of posterior legs, which originate from the thoracic segments, and which possess upon their base peculiar leaf-like appendages. The first pair of legs, starting from the head, might be mistaken for a second pair of maxillary palpi. Galeodes possesses two large projecting ocelli and breathes, like insects, through trachea. Two of the four stigmata open between the first and second pairs of legs, and two on the ventral side of the abdomen.

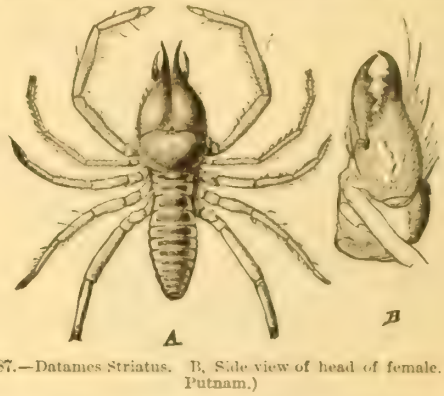

Fig. 2987.—Datames Striatus. B, Side view of head of female. (After Putnam.)

Pallas narrates wonderful stories of one of the species of Galeodes, which is common in Southern Russia, where it is greatly feared and called the Bu-Chorgoi, or Kara-Kart-Bie. People leave a region in which this animal, considered dangerous to man and beast, is common. It is claimed that during the summer, when camels are more or less denuded of hair on their ventral side, these Galeodes appear, and, jumping upon the sleeping animals, poison them. According to the superstition of the Kalmucks, if a person is bitten but one remedy will cure him—the milk of a woman in her first confinement, providing she was immaculate as a girl. If such milk cannot be had, the heart or lung of a black dog or cat is torn out of the living animal and applied to the wound.

Physicians during the time of Pallas effectually used nut-oil, or cotton saturated with camphor. The viciousness of these creatures in attacking when interfered with, as well as the formidable nature of the large mandibles, plainly indicates that they have both the will and the power to inflict a severe bite. No cases have come under our notice, but the bite of some species is said to be very painful, producing violent inflammation, passing lameness, headache, and fainting fits. Experiments that have been made prove the dangerous qualities of the bite, though there is doubtless great variation in this respect in the different species. The many species which occur in this country usually live in sandy deserts, where they dig pits in the soil, removing the débris by means of their mandibles and stiff hairs, which act as a broom. During the day they hide; and they search for their food, chiefly grasshoppers, during the night. The food is not simply sucked dry, but is completely chewed up. Small lizards, young mice and rats, and even specimens of their own kind, do not escape their voracity. Their only redeeming character is the love for their offspring, which they protect carefully.

The best-known American species is the *Solpuga* (*Galeodes*) *americana* Say, which runs with amazing rapidity, like our well-known sand-crab.

Class Myriapoda (Thousand-legs.)—Tracheates with free head and numerous, nearly uniform segments, with one pair of antennæ, three pairs of palpi, and numerous legs.

Thousand-legs are distinguished from all other arthropods by the uniform segmentation of their cylindrical or flat bodies, and the mode of their locomotion. This class is divided into two orders, the *Chilognatha* and the *Chilopoda*. The most important character, so far as we are now concerned, is that the one has its jaws or mandibles formed on the ordinary plan found in hexapods that bite their food; while the other has them formed out of its fore-legs into something half-leg, half-jaw, after the shape of the falces of spiders, with a sharp point and a hollow duct inside, which is connected with a poison-gland. The former compose the *Chilognaths*, with two pairs of legs to each segment; the latter the *Chilopods* or *Scolopendridæ*, with one pair of legs to each segment. The former are harmless, and it is with the latter that we have to deal in this connection.

Order Chilopoda (Centipedes).—Distinguished by a flat body with one pair of legs on each segment; long and many-jointed antennæ; mouth-organs fitted for carnivorous food; poison-glands in base of first pair of legs, which resemble mouth-parts.

Fam. *Scolopendridæ*.—Chiefly distinguished by the relatively few segments and few ocelli.

This family contains the most formidable and largest species, some reaching nearly a foot in length. As stated by Professor H. C. Wood, Jr., in "The Myriapoda of North America," their highly organized muscular and nervous system, the compactness of their intestinal apparatus, and the length and power of their legs, all betoken habits of great activity, while the formidable nature of their mandibles, and the sharp spines, both lateral and terminal, with which their feet are armed, fit them for predatory warfare. The poison-fangs are very strong, and the bite dangerous.

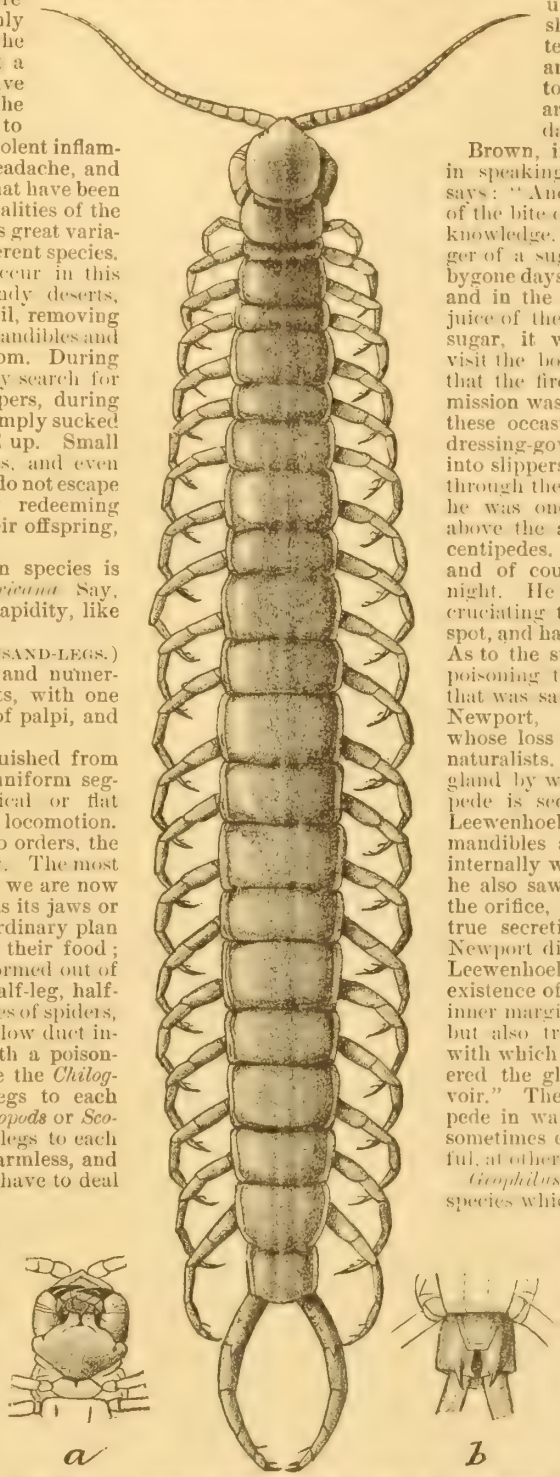

Fig. 2988.—Scolopendra Castaneiceps. *a*, Under side of head, showing fangs; *b*, under side of last segment. (After Wood.)

Brown, in his "History of Jamaica," in speaking of *Scolopendra morsitans*, says: "Another example of the severity of the bite came within our own personal knowledge. The sufferer was the manager of a sugar plantation in Jamaica in bygone days, when there were still slaves, and in the "boiling season," when the juice of the cane is boiled to produce the sugar, it was his duty or practice to visit the boilers during the night, to see that the fires were kept up and no intermission was allowed in the process. On these occasions, he merely threw on a dressing-gown and thrust his naked feet into slippers, while he took a hasty round through the works. While thus engaged he was once bitten on the leg, a little above the ankle, by one of these large centipedes. They are nocturnal animals, and of course most lively and alert at night. He described the pain as so excruciating that he almost fainted on the spot, and had to be assisted into the house. As to the structure of the apparatus for poisoning the wound made by the bite, that was satisfactorily made out by Mr. Newport, the eminent entomologist, whose loss is still deplored by our older naturalists. Until he worked it out, the gland by which the poison of the centipede is secreted had not been shown. Leewenhoek discovered at the apex of the mandibles an orifice that communicated internally with an elongated cavity, and he also saw a drop of fluid exude from the orifice, but he did not discover the true secreting gland, which, however, Newport did, for he not only confirmed Leewenhoek's observation in regard to the existence of a longitudinal opening at the inner margin of the apex of the mandible, but also traced it backward to the sac with which it communicates, and discovered the gland of which it is the reservoir." The effect of the bite of a centipede in warm climates is very variable: sometimes excessively virulent and painful, at others causing little inconvenience.

Geophilus subterraneus is one of those species which have the remarkable property of occasionally (more especially in spring and autumn) secreting a phosphoric substance, which seems to exude from the body, and is left like a shining trail on the spots over which the centipede has passed. The light soon fades and disappears, however. This is the species whose luminosity has been most frequently observed, but there are reasons for believing that the property is common to all the section of centipedes known as *Geophilidæ*, and that it is evolved only at the breeding season. Oviedo, the friend and companion of Columbus, as quoted by

Newport, mentions it in his account of the island of St Domingo: "There are in this island (St Domingo) many kinds of *Scolopendra* or hundred-legs; some are slender and as long as one's finger and like to those of Spain, and these bite and cause considerable pain. There are others of these worms about half the length of the finger and slender, with many feet, and these shine much by night, and leave a light where they go, and may be seen fifty or even one hundred feet off. Yet the whole animal does not shine, but only the joints where the legs spring from the body, and the light is very bright." From this property this species, or the *luciferus* (it is doubtful which he meant), was named by Linnæus *Scolopendra electrica*.

Numerous observations are recorded of myriapods of this section, after having caused lingering headache, having been sneezed forth by men from the nose. As Van der Hoeven says, it is easier to reject these observations than to explain the continued life of these creatures in such unusual situations.

Class Hexapoda (Insects Proper).—Tracheates, with body distinctly divided into head, thorax, and abdomen. Head with two antennæ, and either haustellate or mandibulate mouth. Thorax with normally three pairs of legs, and with either four, two, or no wings. Abdomen normally nine-jointed.

Order Neuroptera (Nerve-wing Insects).—These insects are characterized by having the wings reticulate with numerous veins, so as to look like network.

The order forms two natural divisions, the first including all those which undergo a complete, and the second those which undergo an incomplete, metamorphosis. The order does not contain any poisonous species. The male of *Corydalis cornutus* is feared by the ignorant without cause. Its female can and will nip the fingers, but, not possessing any poison, produces only momentary pain. The *Panorpidæ* (Scorpion-flies) are dreaded by some persons. The males are distinguished by a peculiar anal organ, which very closely resembles the tail end of a scorpion; but it cannot be used for any similar purpose.

Order Orthoptera (Roaches, Locusts, Grasshoppers, etc.).—These insects are characterized by having the front wings straight and usually narrow, pergamenеous, or parchment-like, thickly veined and overlapping at tips when closed; the hind wings large and folding longitudinally like a fan. Transformations incomplete.

This order contains no venomous species. Members of the family *Forficulidæ* (Earwigs) are erroneously considered poisonous by many people; they are perfectly harmless, so far as venomous qualities are concerned. The oft-mentioned fact that they enter the ears of persons sleeping outdoors, is not disputed; but they enter in search of a dark hiding-place.

The family *Blattidæ* (Roaches), so injurious to his property, are perfectly harmless to man himself.

The family *Acrididæ* (Locusts or Grasshoppers) never occasion bodily harm to man, but it is claimed that flights of the migratory African species have at times spread the germs of cholera to regions far away from the seat of this disease. Some members of this family secrete very corrosive juices, which they drop upon the person handling them.

Order Rhynchota or Hemiptera (Bugs).—Insects with jointed beak (rostrum), fitted for penetrating and sucking the juices of plants and animals. Prothorax mostly free. Metamorphoses incomplete.

In this order we have a number of species which are more or less poisonous. Most true bugs (sub-order *Heteroptera*) secrete poison to produce an accelerated flow of their food, either the sap of plants, or the blood of insects and animals. The sub-order Aptera has apparently no organ to secrete such poison, but the saliva itself is more or less irritating, and the bite is not simply a mechanical perforation of the skin.

Sub-order Aptera or Parasitica.—Wingless Rhynchota, with short, fleshy rostrum and broad, cutting setæ; sometimes with rudimentary biting mouth-organs. Thorax ill-defined. Abdomen generally nine-jointed.

Fam. *Pediculina* (Lice).—Schiodte, a Danish entomologist, has, it seems to us, forever settled the question as to whether the louse bites the flesh or sucks blood, and decides a point interesting to physicians, *i.e.*, that the loathsome disease called phthiriasis is a misnomer. From this source not only many living in poverty and squalor are said to have died, but also men of renown—among whom Denny, in his work on the Anoplura, or lice, of Great Britain, mentions the names of "Pheretima, as recorded by Herodotus, Antiochus Epiphanes, the Dictator Sylla, the two Herods, the Emperor Maximilian, and Philip the Second." Schiodte, in his essay "On Phthirius, and on the Structure of the Mouth in Pediculus" (*Annals and Magazine of Natural History*, 1866, p. 213), says that these statements will not bear examination, and that this disease should be placed on the "retired list," for it cannot be produced by mere blood sucking animals, which in this case are only the disgusting attendants on other diseases. He thus describes the mouth-parts of the louse, his studies having apparently been on *vestimenti*:

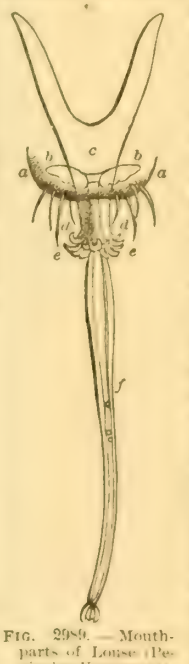

Fig. 2989.—Mouth-parts of Louse (Pediculus Vestimenti). *a*, *a*, The summit of the head with four bristles on each side; *b*, *b*, the chitinous band; *c*, the hind part of the lower lip; *d*, *d*, the foremost protruding part of the lower lip (the haustellum); *e*, *e*, the hooks turned outward; *f*, the inner tube of suction slightly bent and twisted; the two pairs of jaws are perceived on the outside as thin lines. (After Packard.)

"Lice are no doubt to be regarded as bugs, simplified in structure and lowered in animal life, in accordance with their mode of living as parasites; being small, flattened, apterous, myopic, crawling, and climbing, with a conical head, moulded as it were to suit the rugosities of the surface they inhabit, provided with a soft, transversely furrowed skin, probably endowed with an acute sense of feeling, which can guide them in that twilight in which their mode of life places them. The peculiar attenuation of the head in front of the antennæ at once suggests to the practised eye the existence of a mouth adapted for suction. This mouth differs from that of the Hemiptera (bedbug, etc.), generally in the circumstance that the labium is capable of being retracted into the upper part of the head, which therefore presents a little fold, which is extended when the labium is protruded. In order to strengthen this part, a flat band of chitine is placed on the under surface, just as the shoemaker puts a small piece of gutta-percha into the back of an india-rubber shoe; as, however, the chitine is not very elastic, this band is rather thinner in the middle, in order that it may bend and fold a little when the skin is not extended by the lower lip. The latter consists, as usual, of two hard lateral pieces, of which the fore ends are united by a membrane so that they form a tube, of which the interior covering is a continuation of the elastic membrane in the top of the head; inside its orifice there are a number of small hooks, which assume different positions according to the degree of protrusion; if this is at its highest point the orifice is turned inside out, like a collar, whereby the small hooks are directed backward, so that they can serve as barbs. These are the movements which the animal executes after having first inserted the labium through a sweat-pore. When the hooks have got a firm hold, the first pair of setæ (the real mandibles transformed) are protruded; these are, toward their points, united by a membrane so as to form a closed tube, from which, again, is inserted the second pair of setæ, or maxillæ, which in the same manner are transformed into a tube ending in two small lobes placed crosswise. It follows that when the whole instrument is exserted, we perceive a long, membranous, flexible tube hanging down from the labium, and along the walls of this tube the setiform mandibles and maxillæ, in the

shape of long, narrow bands of chitine. In this way the tube of suction can be made longer or shorter as required, and easily adjusted to the thickness of the skin in the particular place where the animal is sucking, whereby access to the capillary system is secured at any part of the body. It is apparent, from the whole structure of the instrument, that it is by no means calculated to being used as a sting, but is rather to be compared to a delicate elastic probe, in the use of which the terminal lobes probably serve as feelers. As soon as the capillary system is reached, the blood will at once ascend into the narrow tube, after which the current is continued with increasing rapidity by means of the pulsation of the pumping ventricle and the powerful peristaltic movement of the digestive tube."

The head-louse (*Pediculus capitis* Deg.) is usually, almost exclusively, found upon the head of children. The well-known "nits," which are glued to the hairs of the host, are the eggs of this species. It is generally supposed that dirt and filth breed these vermin; such is, however, not the case. Of course, upon a dirty head they find more suitable quarters and greater abundance of their appropriate food than upon a clean one. Oil and cleanliness are the best prophylactics.

The body-louse (*Pediculus vestimenti* Burm.) is more frequently found upon the nape of the human neck, and was consequently named, by Linn., *cervicalis*. It is found, however, upon any part of the body not covered with a dense growth of hair. During our civil war it was unpleasantly well known to the soldiers by the characteristic name of "gray-back." The prevalence of this insect during that time was owing to the fact that soldiers were either unable to properly wash their clothing in hot water, or not as often as most of them would like to have done. This insect differs from the other species by a distinct blackish stripe which commences between the hind legs, and reaches about two-thirds of the way to the tip of the abdomen. The male is further distinguished by a very long, robust, and blunt spur at the tip of the front tibiæ.

The crab-louse (*Phthirius pubis* Linn.) is characterized by a much more rounded and flattened shape, and by the four crab-like posterior legs. Its habits are also quite different, although, like the other members of this family, it attaches its eggs to the hair; the young, instead of living on the surface of the skin, burrow under the epidermis, causing intolerable itching. When mature they leave their burrows to procreate.

There is a large number of species affecting our different domestic animals. All, as well as their eggs, can be readily killed by an application to the infested portions of the body of any kind of mercurial ointment.

Fam. *Mallophaga* (Bird-lice).—Distinguished from the lice by possessing three- to five-jointed antennæ, and by a biting mouth instead of a fleshy rostrum.

A great number of species, including the well-known bird-lice, are comprised in this family. They are found upon mammals and birds, and feed upon the young hairs and feathers, but imbibe, in some cases, blood as well.

Sub-order Homoptera (Whole-wing Bugs).—These insects are characterized by having all four wings of a uniform membranous nature, and folding straight down the back when at rest. Transformation incomplete.

None of the species of homoptera are positively known to be poisonous to man, though many produce poisonous effects on plants. The oft-told story of the venomous effect of the puncture, or "sting," of the periodical cicada (miscalled seventeen-year locust) lacks sufficient proof. The matter is fully considered in our writings on this interesting insect, *Cicada septendecim*, with its race *tredecim*. *Cf.* more particularly Bulletin No. 8, Division of Entomology, Department of Agriculture, and Annual Report of U. S. Entomologist for 1884.

Sub-order Heteroptera (Half-wing Bugs).—These insects are characterized by having the basal half of the front wings coriaceous or leathery, while the apical part is membranaceous. The wings cross flatly over the back when at rest. Transformations incomplete.

In this sub-order there are a large number of species which can inflict by their "bite" or puncture severe pain to man and animals. But most of those which possess this power normally live upon other insects. The rostrum or beak of these insects is a horny, pointed, tapering, three- or four-jointed tube, the *labium*, and arises from beneath the front of the head. This tube encloses four stiff bristles, the mandibles and maxillæ, which are adapted to pierce the tissues of plants or animals. In plant-feeding species the rostrum is unusually long and slender; in blood-sucking species it is short, thick, and curved. When plunging the beak into the flesh, the setaceous maxillæ and mandibles—the latter armed with recurved teeth—come into action, and a drop of fluid is discharged at the same time from the salivary glands; this fluid, the poison, is of an acid nature, and will, on this account, produce inflammation and an accelerated flow of blood. It would be useless even to mention all the species involved, and only the more dangerous, or the more common and best-known species, will be referred to in this connection.

Fig. 2990. — Point of Beak of a Hemipteron (Original.)

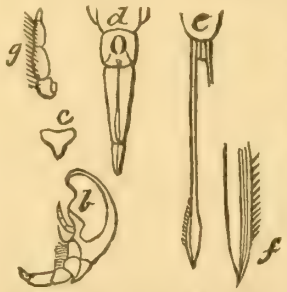

Fig. 2991.—Rostrum of Notonecta. *b*, Side view of rostrum; *d*, rostrum from above; *e*, one of the mandibles entire, and the base of the other and of the two maxillæ; *f*, extremity of mandible more strongly magnified, with recurved teeth; *c*, upper lip; *g*, antenna. (After Westwood.)

Fam. *Notonectidæ* (Water Boatmen).—Aquatic insects, always swimming on their back; they are oval in form, and deeper-bodied than other aquatic bugs, having the convexity of the surface above. Eyes large, reniform; four-jointed rostrum elongate, conical, acute; ocelli absent.

The species of the genus Notonecta have a sharp, poisonous bite. They do not usually attack man, but try to escape from him. If, however, they are roughly handled they bite freely, and occasion very great pain, which lasts sometimes for hours. Ponds that are drying out in summer, and where these species collect in large numbers, should not be used for bathing purposes.

Fam. *Nepidæ* (Water Scorpions).—Flat, elliptical, aquatic insects of a dull, fuscous, or brownish color; legs better fitted for walking than swimming, with the fore-tibiæ curved, carrying a long, one-jointed tarsus, and fitting into a channel of the long and wide femora like the blade of a pocket-knife. Eyes prominent; abdomen terminating in two long respiratory half-tubes, which united serve to convey the air to the interior of the abdomen.

Fig. 2992.—Belostoma Americanum. (After Riley.)

Although these insects are very sluggish in their motions, they should be handled with care, as they are also capable of a sharp and severe bite.

Fam. *Belostomatidæ* (Giant Water Bugs).—The brown or gray insects forming this family contain the largest heteroptera now in existence. They are broad and flat-

bodied aquatic insects, more or less ovate the hind legs being flattened and adapted for swimming, the front tibiæ curved and fitted for seizing and holding their prey.

The *Belostoma americanum* Leidy, since the introduction of the electric light in our streets, has become a rather well-known insect, being attracted to the light in great numbers, and easily stunned by the force of its flight against the lamps. It is injurious to young fish, and its puncture is painful, and, while very rarely wounding man, it should be handled carefully.

Fig. 2992.—Opisthocraus (Belostoma) Pelocoris. *b*, Imago; *c*, larva. (After Riley.)

Fam. *Reduviidæ* (Pirate Bugs).—This family, comprehending a vast number of forms, is distinguished by having the rostrum attached to the tip of the head, with the basal joint bent, thus causing the rest to curve beneath, and usually fitting in a groove upon the sternum. Eyes prominent, hemispherical, lateral, and placed before the base of the head; when situated far back they are succeeded by a constriction resembling a neck.

Nearly all of the numerous species of this family have a more or less poisonous bite. The great majority show, however, but little inclination to bite man, until forced in self-defence to do so. In Europe the Cannibal bug (*Reduvius personatus* Linn.) (Fig. 2993) haunts houses for the sake of preying upon the bed-bug. Recent writers contend, however, that instead of taking the blood from the bed-bugs, they prefer to take it directly from the original source, so that the very commendable propensities of this insect are offset by its making no distinction between bed-bug and man. Its larva (Fig. 2993, *c*) is covered with a glutinous substance to which bits of dirt and dust adhere. Both the imago and the immature larva and pupa have a very peculiar mode of locomotion. They all move very deliberately, step by step, with a long pause between each motion, which is executed in a sudden and jerky manner; their antennæ move at the same rate. If a fly or another insect is offered it is first touched with the antennæ, a sudden spring follows, and at the same time the beak is thrust into the prey.

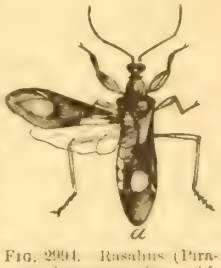

Fig. 2994. Rasahus (Pirates) Biguttatus Say. (After Riley.)

The Two-spotted Corsair (*Pirates biguttatus* Say), Fig. 2994, is in the Southern States found in similar places, and is also said to prey on bed-bugs.

The blood-sucking Cone-nose, or Big Bed-bug (*Conorhinus sanguisuga* Lec.), Fig. 2995, is also frequently found in beds, and its bite is very severe. Prof. J. G. Lemmon, of Oakland, Cal., has reported his experiences with this insect in the Annual Report of the Entomologist for 1884. He was induced, after a botanizing exploration in the mountains of Arizona, to camp with his family in a cave. He writes: "Suddenly Mrs. Lemmon screamed, and a large, flat, nimble-footed bug was seen hurrying away into a rock crevice. It was pitiful to see the tears rolling down her cheeks as she swung her arm about, while applying ammonia to allay the pain of the wound, which immediately reddened and swelled, forming a convex surface one inch or more across." Others were also bitten. The presence of this insect is not felt until the keen beak is inserted; this is very hard, over 3-16 of an inch long, and can, therefore, be inserted through any kind of clothing worn in summer. The swellings made soon fester, occasioning great pain and itching, and discharging pus for several days.

Fig. 2995.—Conorhinus Sanguisuga Lec. *a*, Imago; *b*, pupa. (After Riley.)

Besides these species sometimes found in houses, there are others, seldom or never found under roof, but equally poisonous. As an example we select the *Prionidus cristatus* Linn. This well-known insect, called the "Wheel-bug," on account of the arched and serrated projection on its back, is by no means quarrelsome, but evades man. Its puncture, however, produces violent inflammation, and the bitten hand and arm are rendered useless for some time. Being otherwise a very useful insect, by preying on various other plant-feeding pests, it should be spared and protected.

A species allied to our wheel-bug occurs in Chili, where it is called "winduka," or "rinduka." It is there greatly feared, and if numerous, is said to drive people for a time from their dwelling-places.

Fam. *Cimicidæ*.—These insects are distinguished by a broad head, with the frontal division bluntly rounded; the antennæ have the two basal joints stout, the first being very short and much thicker than the second, while the two end-joints are very slender and pubescent; rostrum slender, excepting the base, and extending to the fore-coxæ.

This family contains as its representative the best-known of all bugs, the bed-bug (*Acanthia lectularia* Linn.). Few people who live in crowded cities will require a figure of this insect in order to recognize it. It is best known as a household pest, but is not infrequently found on some kinds of timber in the woods. Its rudimentary wings and wing-cases indicate that it has undergone a kind of domestication, and has been influenced by man for a very long time. Thus far no individuals of this insect have been met with fully winged, though specimens occur, which have the wing-pads hanging loose, as if ready to change into wing covers. The old Greeks knew it by the name of "koris," and the Romans called it "cimex."

The female deposits about fifty eggs in March, May, July, and September. These eggs are white, 1.12 mm. long, and are hidden in the finest cracks which our rooms afford; behind loose wall-paper, but particularly in recesses which the bedstead affords. Only the full-grown bugs hibernate, or are able to endure a great degree of cold. Nearly the whole year is required for full growth. Notwithstanding their bloodthirsty habits, they can fast for many months. Leunis confined a female in a tight-fitting paper-box, and after six months found the female living and surrounded by a whole brood of young ones—all as transparent as glass.

The judicious use of kerosene or of corrosive sublimate will disinfect a house of this pest.

These nocturnal bugs attack, besides man, chickens, pigeons, swallows, and bats, and it is probable that originally they led a parasitic life outside of human habitations.

The above are the more common Hemiptera or true bugs which come under notice in this country because of their poisonous bite. There are many other species, and beyond the bed-bug, which is ubiquitous, each country has species peculiar to it which the limits of this paper forbid discussing.

Order Diptera (Two-winged Flies).—Insects with sucking or piercing mouth-organs. Two front wings, and two balancers in place of hind wings. Metamorphoses complete.

Sub-order Pupipara (Louse-flies).—Body stout, the three thoracic segments consolidated, abdomen broad and flat. Head immersed in the thorax; antennæ short, frequently but two jointed; claws denticulated; wings present and rudimentary, or entirely lacking. The rostrum is formed by the labium and maxillæ, and contains three pointed setæ.

Some of these parasitic flies live upon the skins of our domesticated animals and birds. If numerous they produce ulcers. These flies are mainly interesting from the fact that they do not deposit eggs, but retain and hatch them in an uterus-like organ. The maggot feeds there upon the secretion of numerous glands, molts several times, and is born just before the last stage has been reached.

Sub-order Brachycera (Flies Proper).—Body of various shapes; head always distinct from thorax; claws not dentated; wings almost always present; antennæ short, usually three-jointed; females oviparous or larviparous.

Fam. *Muscidæ* (House-fly, etc.).—Distinguished by a short, thick, membranaceous proboscis, terminating in two large labial lobes, and retractile within the oral cavity; the proboscis encloses only two internal setæ.

A large number of flies belong to this family, whose bite, and even contact, may produce serious consequences to man. Their usual shape is that of the common house-fly.

The absence of house-flies (*Musca domestica* L.) for a season is believed to be an indication of unhealthfulness. Whatever foundation there may be for this belief is due to the fact that flies are the best and most numerous destroyers of disease-breeding materials. They are scavengers—buzzards on a small scale. Flies consume in their larval state decaying animal and vegetable matter, and the amount of such putrid material in cities is beyond calculation.

The house-fly is in itself not poisonous, but may endanger our lives by carrying disease-germs on its feet and hairy body. Moreover, flies are capable of eating the ova of various parasitic worms, discharging them unchanged in their fæces. The distribution of the human parasite, *Tricocephalus dispar*, as Dr. Grassi has proved, is aided by the agency of the common house-fly. Even the eggs of the tape-worm (*Tænia solium*) may be thus distributed.

Musca Cæsar L., *Musca vomitoria* L., *Sarcophaga carnaria* L., and other well-known, bright-colored flies, may similarly communicate diseases.

The dreaded "screw-worm," of the Southern States, is the larva of *Lucillia macillaria* L. These worms have long been well known to injure and even kill various domestic animals, such as sheep, horses, and cattle. But of late years many cases have occurred where human beings have been the victims as well. The nostrils of man or beast are generally selected by the Lucillia for the deposit of her eggs or the young maggots. People suffering from nasal catarrh, or subject to frequent bleeding of the nose, always run great risk by sleeping outdoors. Professor F. H. Snow has published a long account of the hominivorous habits of this fly in "Psyche." Other papers have been published in the *American Entomologist* and elsewhere. The maggots destroy the soft palate, so that the tongue cannot be protruded and used for speaking. The discomfort to the patient is not very great, until the Schneiderian membrane is affected. The worms burrow under the palatine fascia, which presents a honeycombed appearance, and is entirely destroyed in large patches. After death it was found, in one case mentioned by Dr. J. B. Britton, of Mapleton, Kansas, that all the tissue covering the cervical vertebræ, as far down as he could see by throwing the head back and compressing the tongue, had been wholly destroyed and the vertebræ were exposed. The os hyoides was also destroyed, and the nasal bones were held in position only by the superficial fascia. As many as three hundred maggots were forced in one case from the mouth and nose of a patient before death relieved his sufferings. It is very difficult to reach these maggots when once lodged high up in the ethmoid cells or frontal sinus. Injections with carbolic acid solution of moderate strength, or with olive oil, warm water applications, and a proper use of chloral, are recommended. Pyrethrum is a never-failing remedy for the screw-worms in all cases where they can be reached.

The hominivorous propensities of these flies have gained for them the synonyms of *Lucillia hominivorax* Coquerel, and in South America *L. hominivorus* Cenil.

Quite a number of cases are on record where the viviparous *Sarcophaga* have dropped their young in ulcers of men, causing death. In the tropics a large blue fly, belonging to this family, has the dangerous habit of depositing eggs or living young in the nose, causing severe pain and irritation, and, according to some authors, death. The maggots of *Sarcophaga latifrons* have been removed from ulcers in the ear, and other cases are on record, where such maggots had penetrated the eye, thus destroying its vision.

The *Stomoxys calcitrans*, a member of the family *Stomoxyidæ*, but bearing a close resemblance to the house-fly, is well known by its annoying bite. Though usually found near stables, it does not hesitate to enter houses.

Fam. *Oestridæ* (Bot-flies).—These flies are distinguished by having the mouth completely obsolete, no other traces being visible except two or three minute fleshy tubercles.

Many of these large flies are very troublesome to our domesticated animals. Their larvæ or grubs live either under the skin of their host, or are found fastened to the linings of the stomach, or of intestines, or in the nostrils, and frontal sinuses.

The Ox bot (*Hypoderma bovis* L.) is the best known in this country. The larvæ hatch from eggs deposited by the mother-fly in the hide of living cattle, and produce the ulcers popularly known as "wormals" (worm-holes). Our rabbits are also frequently infested by the similar worms of *Cuterebra cuniculi* Clark, which inhabit ulcers in the neck. The peculiar *Cuterebra emasculator* Fitch, has received this suggestive name from the fact that it mutilates the generative organs of our squirrels.

A bot-fly (*Oestrus hominis* Gmelin, or *Dermatobia hominis* Goudot) is described from South America and Mexico as inhabiting wormals in the human body, the parent fly having every facility for depositing the eggs in the naked bodies of the natives. Foreigners, when bathing, are also attacked. It is not now believed that there is a special bot-fly of man, but the other species, chiefly those attacking cattle, dogs, horses, mules, etc., occasionally infest man. Their grubs have been found in the human scalp, nasal and ear cavities, and also in the stomach.

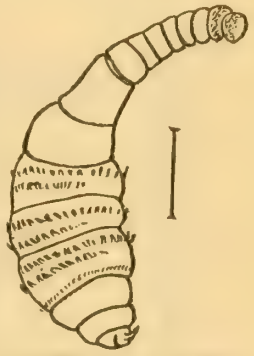

Fig. 2996.—Larva of Dermatobia Noxialis. (From *American Naturalist.*)

The occurrence of dipterous larvæ under the skin of man is more frequent in some countries than in others. In Norway, for instance, the larva of *Hypoderma bovis* is frequently found in such places. It is, however, not normal for these larvæ to exist there, and the situation is so unsuitable that they move about from place to place, resting from time to time long enough to produce an ulcer. Eventually, and generally in early larval life, they break through the skin and perish. Chiefly children from thirteen to fourteen years old are thus afflicted. Parents, to prevent this wandering of the maggot, press a ring over the swelling.

Fam. *Tabanidæ* (Horse-flies, Gad- or Breeze-flies).—These flies are distinguished by the perfect development of the trophi. The exserted proboscis in the female encloses six lancet-like instruments; in the male only four. The proboscis terminates in two fleshy, lip-like lobes, and is covered on the sides by the large, two-jointed maxillary palpi. Eyes very large, frequently beautifully colored; thorax thick and compact; scutellum large and elevated.

These flies are the terror of cattle, horses, and in some regions of man also. Only the females of Tabanus can torment our animals by means of their sharp lances: the males subsist upon the sweets of flowers. The many

species occurring in the United States frequent the neighborhood of marshes, and are most numerous in the prairies. During the hotter parts of the summer, and when the sun is shining brightly, thousands of them fly swiftly about, and frequently torment animals to such a degree as to kill them. Their larvæ, so far as known, are subterranean, or even subaquatic.

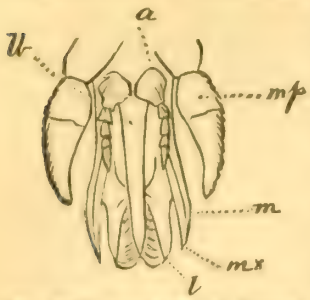

FIG. 2997. Mouth parts of Tabanus. *lb*, Labrum; *a*, mandibles; *mx*, maxillæ; *mp*, maxillary palpi; *a*, basal joint of antennæ; *l*, tongue. (From *American Naturalist*.)

The "Green head" (*Tabanus lineola*), although one of the smaller species, has perhaps the worst reputation of our North American species. In parts of the Mississippi Valley it is impossible to work horses in midsummer without some protecting covering, and in more northern regions even cattle have to be covered. This is especially the case in Denmark, where native species are very tormenting. They often greatly annoy men, especially when bathing.

The Black Breeze-fly (*Tabanus atratus* Fab.) is very large, and though it does not attack horses to any considerable extent, is very troublesome to cattle. It is one of the largest species known, and easily recognized by its black color with a bluish-white bloom on the surface of the abdomen, and by its smoky dark-brown wings. The larva is a large twelve-jointed, cylindrical worm, tapering at each end, of a transparent, highly polished, glassy, yellowish or greenish appearance, with large roundish, retractile tubercles. It is found in moist soil near water

FIG. 2998.—Tabanus Atratus. *a*, Larva; *b*, pupa; *c*, imago. (After Riley.)

or in the water itself, where it preys upon other animals, chiefly mollusks. The cylindrical, somewhat curved pupa is of a pale, semi-transparent, yellowish-brown color.

A related fly, the Tsetse-fly (*Glossina morsitans*), has a world-wide reputation. It is so dangerous that whole regions in Africa are uninhabitable during the season in which this insect abounds. Most animals suffer from its attacks, often dying from the effect, but goats, asses, sucking calves, some wild animals, and man are said to enjoy immunity.

Bruce, in his travels in Africa to discover the source of the river Nile, first figured, in 1790, this insect in "Select Specimens of Natural History Collected in Travels to Discover the Source of the Nile," etc. He gives a very interesting account of its mode of life, and a still more interesting historical sketch of the changes produced by it in the political history of the country where it occurs.

SUB-ORDER NEMOCERA (TIPULIDS, ETC.).—Antennæ composed of more than six joints, usually filiform in the females, plumose in the males; palpi four- or five-jointed; pupa incomplete in Culicidæ and Tipulidæ, complete in Simulidæ.

FAM. *Simulidæ* (BUFFALO GNATS, BLACK-FLIES).—Antennæ eleven-jointed; trophi fully developed, biting; no ocelli; larvæ and pupæ aquatic; metamorphosis complete.

These well-known tormentors are almost as bad as the African tsetze fly just mentioned. In the north the black flies are a very formidable pest, and at times almost prevent travel. They force the Labrador fishermen to spend their summers, very much against their will, on the seaside, as life in the interior is intolerable.

FIG. 2999.—Simulium Pecuarum, Larva. (After Riley.)

A. S. Packard, in "Our Common Insects," relates his experience in these words: "During a summer residence on this coast, we sailed up the Esquimaux River for six or eight miles, spending a few hours at a house situated on the bank. The day was warm and but little wind blowing, and the swarms of black flies were absolutely terrific. In vain we frantically waved our net among them, allured by some rare moth; after making a few desperate charges in the face of the thronging pests, we had to retire to the house, where the windows actually swarmed with them; but here they would fly in our faces, crawl under one's clothes, where they even remain and bite in the night. The children in the house were sickly and worn by their unceasing torments; and the shaggy Newfoundland dogs, whose thick coats would seem to be proof against their bites, ran from their shelter beneath the bench and dashed into the river, their only retreat. In cloudy weather, unlike the mosquito, the black fly disappears, only flying when the sun shines. The bite of the black fly is often severe, the creature leaving a large clot of blood to mark the scene of its surgical triumphs."

The Buffalo Gnats of the South are also a very serious pest to the inhabitants of the lower Mississippi Valley; for, although they do not usually greatly torment man, his cattle, horses, mules, sheep, and even his fowls, suffer terribly, and large numbers of them succumb every season.

The Buffalo Gnat (*Simulium meridionale* Riley) is the best known and largest of the species. It occurs in all the lowland of the valley, extending from the latitude of St. Louis to the northern portion of Louisiana, and east and west along the larger tributaries of the Mississippi River. It appears in swarms nearly every spring, earlier or later, with the inundations, and causes immense losses to the domestic animals. Only the females possess mouth organs adapted to biting. Appearing in immense numbers, they gorge themselves with blood, and this loss of blood, with the terrible irritation of the skin by so many poisonous bites, is sufficient to kill, in a very short time, all but the strongest of the attacked animals. Smoking and greasing is of very little help if the flies are very numerous. Dark stables are the only protection to the stock.

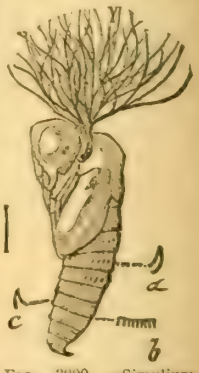

FIG. 3000. - Simulium Pecuarum, Pupa. (After Riley.)

The very peculiar larvæ live in the strongest currents of the creeks and bayous, feeding there, no doubt, upon lower aquatic animals. The peculiar fans on their head, which are in constant motion, serve to create currents of water and thus to draw the food toward the mouth. The pupæ, neatly enclosed in a partially open cradle, are also very peculiar. Instead of having, like the larvæ, breathing organs on the posterior end of the body, they have them upon each shoulder. These organs are composed of forty-eight fine threads closed at the end, and which unite near the base in a stout trunk communicating with

the interior tracheal system. The eggs are laid close to the edge of the water, usually upon the trunks of trees, and hatch soon afterward.

Fam. *Culicidæ* (Mosquitoes).—The family is characterized by having the mouth produced into a slender rostrum, which is about half as long as the entire insect and slightly thickened at tip. The slender antennæ are plumose in the males, pilose in the females. Larvæ and pupæ aquatic; metamorphosis complete.

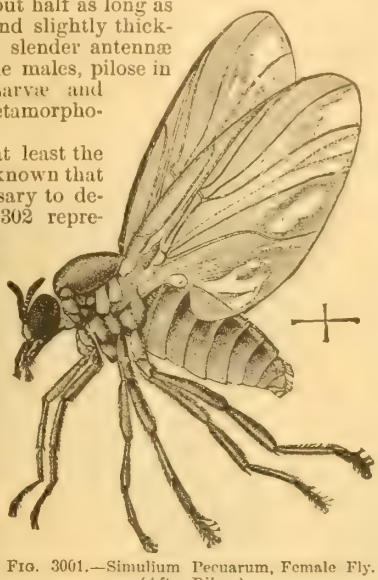

Fig. 3001.—Simulium Pecuarum, Female Fly. (After Riley.)

The mosquito, at least the female, is so well known that it is hardly necessary to describe it. Fig. 3302 represents *Culex pipiens* and its larva and pupa. Numerous species of mosquitoes occur over the whole of the world. They are troublesome in the torrid as well as in the arctic zone, preferring, however, regions with extensive fresh-water and brackish swamps. As stated in our "Little Known Facts about Well-known Animals," they have caused the rout of armies and the desertion of cities, and the hum of an insignificant gnat may inspire more terror than the roar of the lion. The bravest man on the fleetest horse dare not cross some of the more rank and dank prairies of Northern Minnesota in June. It is well known that Father De Smit once nearly died from mosquito bites, his flesh being so swollen around the arms and legs that it literally burst. Those who have travelled in summer on the lower Mississippi or in the Northwest, have experienced the torment which these frail flies can inflict; at times they drive everyone from the boat, and trains can sometimes only run with comfort on the Northern Pacific by

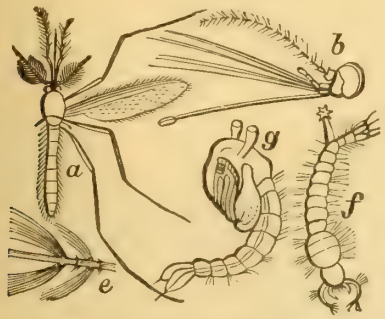

Fig. 3002.—Culex Pipiens. *a*, Male; *b*, head of female; *e*, joints of male antenna; *f*, larva; *g*, pupa. All enlarged. (After Westwood.)

keeping a smudge in the baggage car and the doors of all the coaches open to the fumes."

The young larvæ hatch from eggs deposited upon any stagnant water; the female, in depositing them, supports herself on the water with her four front legs, crossing the hinder pair like the letter X. The minute eggs, just perceptible to the naked eye, are glued together so as to form a little boat, which floats about till the young hatch. These young wrigglers or wriggle-tails can be seen in every tub of rain-water that has stood uncovered for a week during any of the summer months. The full-grown larva (Fig. 3002, *f*) breathes by means of a tube at its posterior end, and to do so has to come to the surface of the water. This habit can be utilized to kill all the wrigglers by means of a very little oil, which spreads over the surface of the water and effectually kills them. After throwing off the skin a few times, the larva changes into a pupa (Fig. 3002, *g*), which breathes by means of tubes upon its back. In this state they are no longer able to do anything but patiently float with their humped backs at the surface of the water, or to swim by jerks of the tail beneath. At the end of about three days they stretch out on the surface like a boat, the mosquito bursts the skin, and gradually works out of the shell which supports her during the critical operation. She rests with her long legs on the surface for a few moments, till the wings have expanded and become dry, and then flits away. The larvæ of the mosquito are great scavengers in infancy, by purifying the water; they perform in this way an indirect service to man, which few, perhaps, appreciate, but which somewhat atones for their bad habits in maturity.

The rounded head of the mosquito has two eyes, almost meeting on the top. Two long, delicate, hairy antennæ (*a*), quite different in the two sexes, start from the forehead. Just below arises the long beak, which consists of the bristle-like maxillæ, *mx*, with their palpi, *mp*, and mandibles, *m*, and the compound hair-like la-

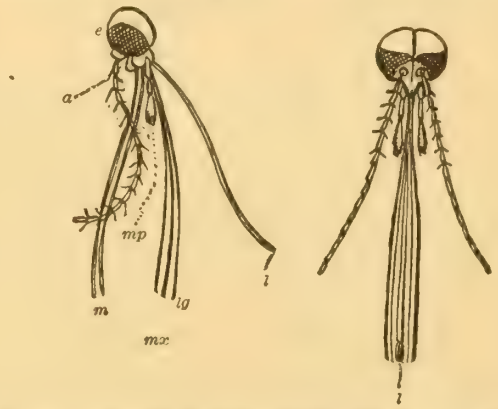

Fig. 3003.—Mouth-parts of Female Mosquito, Front and Side View. *a*, Antennæ; *mx*, maxillæ; *mp*, maxillary palpi; *m*, mandibles; *l*, labrum; *e*, eyes. (After Packard.)

brum-epipharynx, *lr*; these five bristle-like organs can be laid together and are hidden in the hollowed labium, *l*. Massed together into a single, awl-like beak, they are all, excepting the labium, thrust into the flesh.

The irritation and subsequent swelling is not simply made by the tearing of the mouth-parts in the skin of the victim, but by a poisonous saliva, which is very probably injected through a duct in the hypopharynx. At least no irritation is produced, even in very sensitive parts of the skin, when the insect fails to strike blood.

Sub-order Aphaniptera (Fleas).—Body compressed laterally, with separated thoracic segments; no wings, but instead two scaly plates on the sides, those on the metathorax being largest; antennæ very short. Mouth formed for suction; mandibles and lingua long and setiform; maxillæ small, triangular scales with four-jointed palpi; labium minute, with three-jointed palpi. Larva vermiform, pupa inactive.

Fleas are wingless flies. The fleas which torment man (*Pulex irritans*) are less common in bedrooms in this country than in Europe; but other species are often extremely troublesome out-doors, especially in sandy soils in the Mississippi Valley and in Southern California. The shape of the flea is well known to most people, for even where no personal annoyance has been experienced, a pet, a dog or cat, will be apt to introduce it to notice. The body of the flea is much compressed, and there are minute wing-pads, instead of wings, present in some species. The legs are very powerful, enabling the flea to jump enormous distances measured by its size. The

larvæ of fleas are long, cylindrical, and white; they are composed of thirteen segments, exclusive of the head, and are provided with rather long hairs. The larva is very active in all its movements, feeding on dry blood and other animal matter, such as dead flies, which are frequently found on the unswept floors of outhouses or in the bed straw of the animals they infest. It requires but a short time to mature a brood of fleas in warm weather; they remain about six days in the egg, a few days in the larva, and about ten days in the pupa, state.

The different species of fleas inhabiting northern countries may be at times very troublesome, but are trifling compared with their tropical relative, the sand flea, alias jigger, chigoe, chique, biche, or pique (*Sarcopsylla penetrans* L.). This flea is very commonly found in sandy places along the rivers of South America, and prefers the vicinity of old camping grounds of the Indians.

Fig. 3004.—Sarcopsylla Penetrans. A. Female, before entering host. B. Female, several days after entering host. C. Front view of swollen female. (After Karsten.)

Both sexes imbibe blood freely, the bite being very irritating, and often producing large swellings. The female penetrates under the nails, especially of the toes, where her abdomen swells to about the size of a pea. Here about sixty eggs are deposited in a sort of sac, and the young hatch and feed upon the swollen body of their mother until they are full grown, when they escape to the ground.

The natives, not wearing shoes, have their feet much hardened, and seem not to mind these intruders, which produce no especial pain in penetrating. If once under the nail, and not disturbed, no serious consequences take place; but if in removing the swollen skin of the flea it is ruptured, distressing sores frequently result.

Order Lepidoptera (Butterflies, Moths).—Characterized by having four branching-veined, membranous wings, each more or less densely covered on both sides with minute imbricated scales which are attached by a stalk, but which easily rub off, and appear to the unaided eye like minute particles of glistening dust or powder. Transformation complete.

The insects of this order, in their mature or winged state, are all non-poisonous, and it were unnecessary to mention them here, did not some of their caterpillars or larvæ possess urticating and poisonous qualities.

In most species the irritation produced is of a mechanical nature, but in others there is a truly poisonous quality. Some of the large horn-tailed larvæ of the *Sphingidæ* (Hawk-moths) have acquired a reputation, in the popular mind, for being poisonous, *e.g.*, the common green tomato-worm (*Macrosila 5-maculata*). There is not a particle of foundation for such belief, as none of these sphinx worms can penetrate the skin, and the brown juice dropped from their mouth, when roughly handled, is perfectly harmless.

The caterpillars which possess poisonous and urticating propensities belong, for the most part, to three families: (1) the Bombycidæ, or spinners, which have, as a rule, long hairs and spin a cocoon; (2) the Saturniidæ, which are spinous rather than hairy; and (3) the Conchliopodidæ, or slug-worms, which have both spinous and hairy representatives, and which are characterized by the flattened venter and short legs, which induce a slug-like locomotion. In the first category the source of irritation is either a powder secreted from the general surface, or the hairs, both of which are mixed with the cocoon. In the second, it is a poisonous quality of the spines themselves, and in the third, the evidence seems to point to a secreted poison injected through the spines as instruments.

The Processionary caterpillars of the oak (*Cnethocampa processionea*), and other related species on the pine, are greatly feared in Europe, and not without cause. The whole external surface of the skin secretes an acrid juice, which dries over the body in a farinaceous form, and

Fig. 3005.—Saturnia Io. Male moth, natural size. (After Riley.)

which produces acute irritation upon contact, especially with the more delicate surfaces, through inhalation. Workmen who are occupied in woods where this caterpillar is numerous, have been known to sicken rapidly from this cause. The long hairs, under the microscope, are seen to be branched, and are said to be filled with a form of formic acid. When broken off in the human skin, they produce a terrible itching and burning sensation. There are many cases on record, where such hairs have found their way by some means to the interior organs of people or animals, producing dangerous inflammation, resulting even in death. Cattle, which like to rub themselves against trees, sometimes come in contact with the cast-off skins of these caterpillars, and become perfectly frantic.

In Brazil, a species, probably yet without a name, or which we have not yet determined, acts in very much the same way, but produces greater irritation and pain. Mr. Albert Koebele, who did some collecting for us there in 1883, found the irritation almost intolerable, and that there was no escape from it so long as the larvæ, dead or living, or the cocoons, were anywhere in the neighborhood. This caterpillar is nearly three inches long, entirely black with white stigmata; each segment is armed with eight long, bright orange-yellow, very stout spines, which

Fig. 3006.—Saturnia Io. Female moth, natural size. (After Riley.)

divide at the very base, and toward their tips into numerous smaller bristles which point in every direction, thus protecting the entire surface of the caterpillar.

Here, in the United States, we happily have no caterpillars quite so dangerous, but there are a number which possess more or less severe urticating power and which produce severe pain. The caterpillars of *Saturnia Io* and *Hemileuca maia* are among the largest. The poisonous

quality in these cases seems to rest in the composition and structure of the spines themselves, rather than in any secretion connected with them.

The Io Moth (*Hyperchiria Io*) is one of our most beautiful moths, receiving its name from two conspicuous eye-spots on the hind wings, in allusion to the ancient Greek heroine, Io, who, as the fable went, was jealously guarded by the hundred-eyed Argus. The sexes differ remarkably in coloration. The smaller, male, is much brighter colored, being of a deep yellow, marked with purple-brown, the body and hind wings being of a deeper ochre-yellow. In the female, the purple-brown color pre-

Fig. 3007.—Hyperchiria Io. Larva, natural size. (After Riley.)

dominates, and she is somewhat differently marked. The cream-white eggs, with a small black spot on the apical end, are deposited in clusters on the underside of various leaves, such as willow, poplar, and others. The full-grown caterpillar is of a green color, with the longitudinal stripes at the sides white and lilac-red. In our experience the urticating properties of this larva, which exist from the first stage, are keener than in *maia*. At all events it cannot be handled with the same impunity; for it has fewer of the bristle-ending spines, and more of the stout and acute spines which prick most readily. Dr. Geo. Dimmock published an account of certain protrusile organs of this larva in "Psyche," vol. iii., p. 352. They are found on the fourth and tenth segment, a trifle below the level of the stigmata. When retracted they look like an irregular opening, about half a millimetre in diameter; if the larva is irritated, these openings will be seen to evaginate and to re-invaginate alternately. These organs are probably the openings of glands, and may be used to drive away some parasites, but are not connected, it seems, with any urticutating powers of the caterpillar.

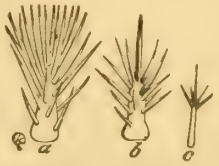

Fig. 3008.—Hyperchiria Io. Enlarged poisonous hairs. (After Riley.)

The Buck Moth (*Hemileuca maia*) is a truly elegant moth, which flies in midday late in October and November. The color of its wings is that of crape, banded with cream-white; its body is of the same black color, but is sprinkled with white, and has a cream-white collar; the male has a large tuft of brick-red hair at the tip of the abdomen. The pale greenish-cream eggs are deposited in naked, somewhat spiral, belts of from one hundred to two hundred around small twigs of oak. The caterpillar produced from them is brownish-black, covered with more or less conspicuous small oval, yellow elevations or papillæ, with a lateral yellow stripe formed by the confluence of some of the papillæ and by broken, irregular yellow marks.

The Conchliopodidæ contain more urticating larvæ than any other family or group of Lepidoptera, the stinging property resting in the more minute, short, and soft spines, which either beset the larger spines or lie close to the body, hidden at times by soft and harmless hair. The common "Saddle-back," a characteristic brown larva with a green "saddle," and producing a rich-brown moth (*Empretia stimulea* Cl.), will serve as an illustration of the former; and the equally characteristic larva of a woolly, cream-white moth (*Lagoa opercularis* Harr.), with its long soft hair under which are hidden the bunches of short stinging spines, is typical of the latter. In the tropics some related species attain large size, and are much dreaded by the natives.

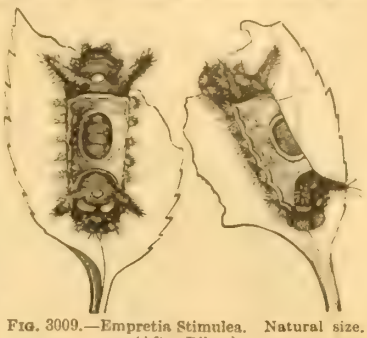

Fig. 3009.—Empretia Stimulea. Natural size. (After Riley.)

A few Noctuidæ possess in the larva state this stinging property in diminished degree—especially in the genus *Acronycta*, as we have shown in *A. xyliniformis*, and under exceptional circumstances, all hairs or spines that are barbed may produce more or less inflammation.

Order Coleoptera (Beetles).—Characterized by having four wings, the front pair horny or leathery, and usually united down the back with a straight suture when at rest, the hind ones membranous and folded up under the elytra when at rest. Transformations complete.

None of the insects of this Order are known to have poisonous bites. The larger specimens, by means of powerful, hard mandibles, can bite severely, but no poison is secreted, and only a momentary pain without subsequent inflammation is the result. But quite a number of beetles possess chemical properties, which may, under certain conditions, blister or poison persons who handle them carelessly.

Among the *Carabidæ* or ground-beetles, the bombarding-beetles (genus *Brachynus*) have a peculiar method of defence from their enemies. They eject from the posterior part of the body an acrid gas or vapor which, when condensed, becomes a yellowish-red fluid which is strongly acid, as shown by the litmus-paper test.

Some other *Carabidæ* also secrete a rather poisonous fluid, which issues from their mouth; some of the *Chrysomelidæ*, upon being disturbed, produce drops of a nasty, sometimes pungent, fluid, while some of the large water-beetles (*Dytiscidæ*) secrete a very offensive-smelling liquid, which is ejected at the moment of danger. But the only truly poisonous beetles are the vesicants belonging to the family *Meloidæ*.

Fig. 3010.—Macrobasis Unicolor. Male, natural size. *b*, Beetle; *c*, enlarged male antenna. (After Riley.)

The Spanish fly (*Cantharis vesicatoria* L.) is well known to every physician. It occurs everywhere in the temperate regions of Europe; its life-history is as yet not completely known, though the larva has been artificially fed by Lichtenstein on honey and bee-bread; and the presumption is that it is parasitic in the cells of certain mason-bees. We have numerous species of blister-beetles in this country, and chiefly on our western plains, where their larvæ, as we have shown, feed upon the eggs of locusts.

This habit was suspected by us in 1876, and was first demonstrated in 1877. All blister-beetles are elongate in form, and possess the property of drawing blisters on human flesh. Many of the species show great partial-

ity to the potato, and were for a long time considered the most formidable enemies of this esculent. Careful examination of locust eggs in the vicinity of potato-fields frequented by these beetles, show a varying proportion of the egg pods affected, and in some locations

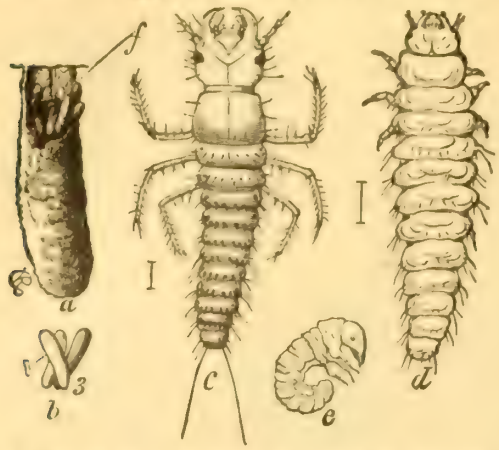

FIG. 3011.—*a*, Egg-pod of Caloptenus Differentialis, with the mouth torn open, exposing the newly hatched larva *f* of Epicauta Vittata eating into an egg: natural size; *b*, eggs of E. Vittata, the natural size indicated at side; *c*, dorsal view of the first larva, or triungulin of E. Vittata, greatly enlarged; *d*, dorsal view of second larva of E. Vittata; *e*, side view of the second larva, showing its natural position within the locust-egg mass. (After Riley.)

nearly every pod of the differential locust (*Caloptenus differentialis*) will contain the blister-beetle larva. The eggs of this locust are laid in large masses of seventy to about one hundred. From July to the middle of October the eggs of the beetles are laid in the ground in loose,

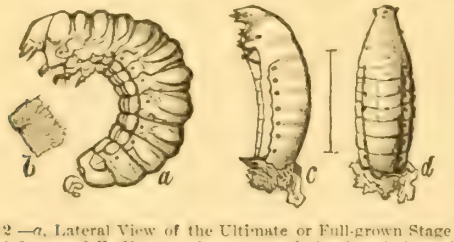

FIG. 3012.—*a*, Lateral View of the Ultimate or Full-grown Stage of the Second Larva of E. Vittata; *b*, portion of the dorsal skin, showing short setaceous hairs; *c*, lateral view of the pseudo pupa or Coarctate Larva of E. Vittata, with the partially shed skin adhering behind; *d*, dorsal view of same. (After Riley.)

irregular masses, the female excavating a hole for the purpose. In the course of about ten days the larva, or triungulin, hatches. This triungulin is at first feeble and perfectly white, but soon assumes a light-brown color and commences to move about very rapidly, prying, with its large head and strong jaws, into every crease and crevice in the soil, into which, in due time, it burrows. Reaching a locust egg-pod, it tunnels through the mucous covering and makes its first repast thereon. By the time the contents of an egg are consumed, the body of the parasite has perceptibly increased. After eating a second egg, and passing a period of rest, the triungulin skin splits along the back and the second larva issues, being white, soft, with reduced legs, and quite different in general appearance from the first. After feeding for about another week, a second molt takes place, the modification at this molt is slight, but the mouth-parts and legs become rudimentary. Another six or seven days elapse, and another molt takes place, without producing any material change, except in size. In another week it forsakes the remnants of the egg mass, and burrows a short distance in the clean soil, where it forms a smooth cavity within which it lies stretched on one side, motionless and gradually contracting. The skin separates and becomes loose at the end of the third or fourth day, when it splits on the top of the head and thoracic joints and is worked toward the extremity, but never fully shed. The mouth-parts and legs are now quite rudimentary and tuberculous, the soft skin rapidly becomes rigid and of a deeper yellow color, and we have now a pseudo-pupa. In spring this skin is rent on the top of the head and thorax, and from it crawls the third larva, which differs in no respect from the ultimate stage of the second larva already mentioned, except in the somewhat reduced size and greater whiteness. This third larva is rather active, and burrows about in the ground. In a few days it changes to a true pupa, and after a rest of five or six days the winged form is assumed.

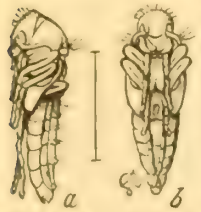

FIG. 3013.—*a*, Lateral View of the True Pupa of Epicauta Cinerea; *b*, ventral view of same. (After Riley.)

ORDER HYMENOPTERA (BEES, WASPS, ETC.).—Characterized by having four membranous wings with comparatively few veins, the hind pair smallest; mouth-parts fitted for either biting or sucking (licking); a compact and consolidated pro-thorax. Metamorphosis complete.

The most aggressive and venomous insects are found in this order. The sting is the chief weapon of defence. It is always either the female or the so-called neuter which possess the sting, which is in fact but a modified ovipositor; the males never have it.

In the *Terebrantia*, in which the females possess a long, exserted ovipositor, the parasitic species may be briefly referred to, since some of the species, although usually small and weak, can sting and occasion considerable pain. Their normal habit is to use the sting as an ovipositor, by means of which they insert their eggs into, or on, or near various phytophagic larvæ. The species of the genus *Ophion* occasionally sting persons who handle them, and produce a violent but transient pain.

It is among the *Aculeata*, however, the highest organized of insects, that we find the most perfect stinging apparatus connected with a poison-gland.

The well-known and almost omnipresent ants (*Formicidæ*) need no special description. Both females and workers (the latter simply sexually dwarfed females) possess stings with poison glands. Some of our native species both bite* and sting readily, and occasion violent pain. But in the tropics ants reach their maximum size, and are not only very numerous but also very aggressive. They sometimes attack man and beast with blind fury, inflicting severe pain, and even causing death when in great numbers.

The so-called cow-killers (family *Mutillidæ*) are bright-colored, usually brilliant red, insects, and look in their unwinged forms very much like stout, hairy ants. They are very poisonous. The sting is almost as long as the body, and some of the species are very aggressive. Unlike the social ants, they are usually found running about singly in open fields, in sandy places, and during the hottest part of the day. They are very bold and seem conscious of their power to withstand the attack of larger animals, for the body-wall is so hard and tough that it is difficult to crush. The sting produces violent inflammation, fever, and lameness, and as the popular name indicates, cows are supposed to be killed by it in Texas.

The fossorial or digger-wasps (family *Sphegidæ*) have all a more or less poisonous sting. Their usual mode of life is such that they need such a weapon. Although living in their winged state upon pollen and honey of plants, their young must be fed with fresh flesh. The mother wasp, having prepared a cell in the ground or elsewhere, or having built one from clay or other material, selects a spider, worm, fly, beetle, or other insects that are suitable (and each species has its own peculiar taste in this matter), and stings its victim just enough to paralyze it, when it is carried to the prepared cell, an egg deposited upon or near it, and the cell closed. The egg in time hatches, and the wasp larva feeds upon the liv-

* Many ants possess no stings, but they can inflict poisonous bites with their mandibles, injecting formic acid in the wound.

ing, yet helpless, food, thus carefully provided by its parent.

Some of our largest wasps belong to this family. In the Middle or Southern States the large digger-wasp

Fig. 3014.—Digger-wasp (Stizus Grandis). (After Riley.)

(*Stizus grandis*) is a rather common feature. This wasp stores its nest with cicadas, often much larger than the wasp itself. Any one who has heard the cries of agony of a cicada stung by this wasp will never forget it. Two or more stings inflicted by this insect at the same time upon man might readily endanger his life. The bite of a scorpion is not more dangerous, and it is fortunate that these wasps are not aggressive. Strong, active, and rapid in their motion, clad in a bright and well-fitting uniform, with keen senses, and armed with terrible weapons for offence and defence, they would be dangerous indeed if they normally attacked man. Entomologists, although accustomed to capture all kinds of poisonous wasps without fear, hesitate to try their net upon this species.

Fig. 3015.—Blue Digger-wasp (Chlorion Cærulium). (After Riley.)

Fig. 3016.—Pepsis Formosa. (After Riley.)

Other larger and brilliantly colored species occur everywhere in the United States. The common Blue Digger-wasp (*Chlorion cærulium* Drury) is frequently found flying about houses in quest of spiders, with which it provisions its nest in the earth. The hole in the soil, previously made for the reception of a spider, is so carefully hidden after being filled with the victim, that without having marked the exact place it would be impossible to detect it.

The Ichneumon-like Digger-wasp (*Sphex ichneumonea* L.) is more common in the Northern States, and occurs more frequently upon flowers. It fills its nest with the young of our common grass-green meadow katydid.

Another gigantic digger-wasp (*Pepsis formosa* Say) has the useful habit of stinging the poisonous tarantula of Texas in such a way as to render it entirely defenceless; it is then carried to a hole in the ground prepared beforehand, and consumed by the soft larva of the Pepsis, which is hatched from an egg laid by the female before closing the nest. On account of this habit it is called in Texas the "tarantula killer."

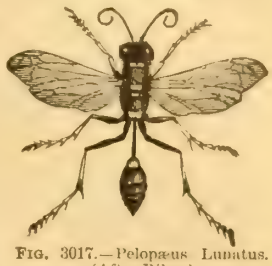

Fig. 3017.—Pelopæus Lunatus. (After Riley.)

The mud-daubers are well known to most people. Our common *Pelopæus lunatus* Fab., is often found in outbuildings, where it constructs a nest of tempered clay, affixing it to the interior walls or to overhanging cliffs. In search of moist clay for this purpose, it may often be seen, during a long dry spell of summer weather, perched on the ground in the neighborhood of wells and other wet places. The mud-dabs are composed of one or more layers or tiers of clay tubes, arranged side by side and cemented on to some surface well protected from the weather. The cells are provisioned with spiders, which form the food for the one maggot bred in each cell.

Fig. 3018.—Vespa maculata. (After Riley.)

The paper wasps (family *Vespidæ*) are familiar to all, and most people have been convinced by actual experience that their sting is poisonous and quite painful. Members of this family lead a similar mode of life to that of the digger-wasps. They live also upon pollen, honey, and the juices of fruit; but their young require animal food, which is brought them by the workers or by the females themselves. The sting with which they are provided is therefore not used to procure and prepare the food, but to defend themselves,

Fig. 3019.—Polistes. (After Riley.)

and to revenge some imaginary affront. It is not barbed, and may, therefore, be used repeatedly.

The Bald-faced Hornet (*Vespa maculata* L.) may be taken as a familiar example of the habits of this group. Their nests, made of sheets of strong, gray, weather-proof paper, are suspended from the branches of trees, and some of them when completed are much larger than a man's head. Each nest, whatever be its location, is suspended from some object above it by a single strong pillar. Inside, combs or layers of hexagonal cells are

placed, each suspended from above it by numerous little pillars of the same *papier maché* that the insect employs in all its architecture—thus leaving an open passageway between the different tiers. These combs, constructed of the same paper like substance, and not, as in the case of the honey bee, of wax, differ further from those of the honey bee in their horizontal position, and in containing each of them but a single layer of hexagonal cells, with their mouths opening downward. The cells are used exclusively for rearing the larvæ.

The yellow jackets, such as *Vespa vulgaris* and *V. germanica*, have similar habits. The more slender species of the genus *Polistes* build their combs in spots partially sheltered from the weather, but always without any paper envelope, and usually with but a single comb to a nest.

All wasps guard their nests with great care, and if any foreign body approaches all those upon the nest stand quite erect upon their legs, turn their heads toward the intruder, and make a humming noise with their rapidly vibrating wings. It is now time for the intruder to leave the spot; to touch the nest would give them the signal for attack. Hornets and wasps were well known to the Greek and Roman writers. Plautus repeatedly uses the expression "Crabrones irritare," perhaps thus indicating personal experiences. The impudence and rashness of both hornets and wasps are well known. They enter our rooms, creating terror, to obtain a fly, a spider, a bit of meat, or sugar and fruit, and do not in the least mind the persons present. They are very fond of ripe fruit, and do not wait, like honey-bees, until the skin of the coveted food breaks, but, using their jaws, they force their way to the juicy portions. The honest working-bee, which is attracted to this spread table, has usually to take all the blame. Wasps are always in a feverish haste, which is not to be wondered at, considering the large nests made by them in the course of one summer. During autumn we find, besides the workers, males and females. After pairing, and when the workers become old and weak, they are seized with a very peculiar frenzy; in blind fury they turn their murderous instincts against their own family, and the larvæ and pupæ, so well taken care of before, are now mercilessly torn from their cells and thrown to the ground to perish. All order ceases. The fertilized females escape and find suitable hibernating quarters in the ground, under moss or dead trees; all the rest succumb to the first frost.

The larvæ of all wasps are chiefly fed with animal food. Like a bird of prey, the hornet pounces upon its victim, throws it to the ground, cuts off legs and wings, and carries the still quivering insect to a branch of a tree, where all the soft parts are removed; after being chewed very fine, they are rolled into a ball and carried home to the nest. Arrived, the food is again chewed and cut into small pieces, which are laid upon the mouths of the helpless larvæ.

FIG. 3020.—Sting of Bee. Enlarged. *a*, Tip of lancet, still more enlarged. (After Gosse.)

FAM. *Apidæ* (Bees).—Most of the bees, though not so spiteful as the wasps, know perfectly well how to use their defensive weapon, and the pain inflicted by them is quite severe. Only the so-called workers have such stings. The good-natured bumble-bee, and the useful honey-bee, belong to this family. Many species lead a solitary life, others live in smaller or greater communities. The parents and their offspring feed upon pollen and honey.

The gigantic Carpenter Bee (*Xylocopa carolina* L.) is well known by its habit of boring numerous holes in such parts of timbers as are neither whitewashed nor painted. At the bottom of one of these holes, which are often many inches deep, they deposit provisions consisting of pollen for their future larvæ. These bees also make holes in partially decayed wood, but wherever the bark covers the wood, there they refuse to bore. Carpenter bees are usually mistaken for large bumble-bees, though they are solitary and not social as the latter. Their polished abdomen, uncovered with any hair, distinguishes them at a glance from bumble-bees. Their sting is very painful, and they should not be interfered with when flying over porches. The best way to keep them away is by painting the woodwork.

Charles Valentine Riley.

POISONS. A concise definition of the term poison, which will satisfy the medical, the legal, and the popular acceptations, is a practical impossibility. To the layman a poison is any substance which, when administered in small doses, will cause disturbance to health or destruction of life; in a legal sense it is any substance of a destructive or noxious character, whatsoever its nature or mode of operation, which, taken into the system, will produce injurious or fatal effects. The popular definition excludes many well-recognized poisons which act injuriously only in large doses; the legal includes, or may be made to include, many substances not strictly poisonous, such as powdered glass, iron filings, and other things of a similar character, which are nothing more than mechanical irritants. To the physician and toxicologist the term means any substance of inherent deleterious character, either organic or inorganic, and incapable of self-reproduction, which, acting chemically upon the tissues or fluids of the body, may, by causing alteration or destruction of the same, or disturbance of function, seriously affect the health or destroy life. This definition excludes mechanical agencies, direct thermal changes, electricity, bacteria, and the low forms of animal life.

The published statistics of poisoning are very meagre, but the few tables which we have are interesting in several directions, indicating the classes of substances and special substances most frequently selected or accidentally administered, at different times and in different countries, and showing the proportion of accidental, suicidal, and criminal deaths due to poisoning.

The returns made by the English coroners of the inquests held during 1837 and 1838, showed the whole number of deaths by poisoning to be 541. Of this number opium was the cause in 196 cases, the majority of which were accidental or suicidal. Arsenic stood next in order, with 185 cases, the majority of which were criminal. Thirty-two cases were due to sulphuric acid, 27 to prussic acid, 19 to oxalic acid, and 15 to corrosive sublimate and other preparations of mercury.

During the years 1863 to 1867 there occurred in England and Wales 2,097 deaths from poison. Of this number no less than 628 were due to opium and its preparations, 151 to prussic acid and potassic cyanide, 83 to arsenic, 77 to mineral acids, 66 to oxalic acid, 61 to strychnine, 58 to compounds of mercury, 15 to phosphorus, and 11 to ammonia.

In France, during the years 1851 to 1871, out of 873 cases, 287 were by arsenic, 267 by phosphorus, 159 by copper, 36 by sulphuric acid, 35 by cantharides, while opium and its preparations were responsible for but 6.

In Finland, of 30 fatal cases occurring between 1860 and 1866, arsenic stood first with 7, phosphorus second with 5, and strychnine third with 4.

Out of 45 cases reported in Massachusetts during 1878 to 1881, opium was responsible for 18, arsenic for 13, and all others for 14.

Although poisoning is a frequent means of suicide, the percentage of these cases is not nearly as high as is generally supposed; but yet, judging from what figures we have been able to obtain, this method of terminating an unsatisfactory existence is gradually becoming more popular. In Prussia, for instance, while there was a great increase in the number of suicides from all causes during 1871 to 1876, the relative frequency of self-poisoning was very much greater. The increase from all causes over preceding years was 43.60 per cent., but suicide from poisoning alone had more than doubled in frequency, the

increase being 126.10 per cent.; but, even then, poisoning was the means employed by but a fraction over three per cent. of the whole number of suicides. During the eight years ending with 1876, the whole number of these cases was 24,918, and of this number 786 were by poisoning (3.15 per cent.). Solid or liquid poisons were elected by 707 persons, and gaseous by 79. It is interesting to note further that, while by far the greater number of suicides were men, the proportion being 80.50 against 19.50, or more than 4 to 1, the 786 suicides by poison were nearly evenly divided between the two sexes, the proportion being 52.9 men to 47.1 women.

Of the whole number of suicides reported in Bavaria during the fourteen years ending with 1870, two per cent. were due to poisoning. In 1871 the percentage increased to 3.2; during 1872 it was 3.00; in 1873 it fell to 2.20; increased again in 1874 to 2.70, and fell off again slightly in 1875 to 2.50. The popularity of poisoning as a means of suicide varies greatly with different countries. In Sweden, during 1843 to 1855 nearly a fourth of the suicides chose this means (21.7 per cent.); in England, in 1858 to 1859, 9.10 per cent.; and in other countries as follows: France, 1835–44, 2.48 per cent.; France, 1848–57, 1.80 per cent.; Belgium, 1840–49, 1.80 per cent.; Denmark, 1840–56, 1.50 per cent.; Würtemberg, 1857–70, 1.20 per cent.; Geneva, 1838–55, 4.90 per cent.

Of the accidental deaths occurring in Prussia during 1869–1876, 54,363 in number, 2,448, or 4.50 per cent., were due to poison. This number includes 1,873 men and 575 women; 348 of the victims were under, and 2,100 over, fifteen years of age. During the fifteen years ending with 1877 there were 77 cases of criminal poisoning in Prussia, or 0.056 per cent. of all crimes. In France, during 1826–29, out of 2,663 capital offences, 150, or 5.63 per cent., were for poisoning. In England and Wales, during 1840, there occurred 349 deaths from poisoning (181 men, 168 women); 161 cases were suicidal (74 men, 87 women); and 188 were accidental and homicidal (107 men, 81 women). Among the latter opium caused death in forty-two children under five years of age.

Classification.—Various methods of classification of poisons have been, from time to time, recommended; but no system has, as yet, proved quite satisfactory. The old classifications, according to source or chemical properties, such as: 1, animal; 2, mineral; 3, vegetable; or, 1, organic; 2, inorganic; or, 1, acids; 2, alkalies; 3, salts, are of no value, since they convey no idea regarding the properties of a poison, or its mode of action. Orfila's division into 1, irritants; 2, narcotics, and 3, narcotico-irritants; Tardieu's into 1, irritants and corrosives; 2, hyposthenians; 3, stupefacients; 4, narcotics, and 5, tetanics; and Taylor's into 1, irritants, and 2, neurotics are all good, but each has its defective points. Taylor's is, perhaps, the best. The irritants are derived from the animal, vegetable, and mineral kingdoms; those from the latter source may be further subdivided into acid, alkaline, non-metallic, and metallic. The neurotics are subdivided into 1, cerebral; 2, spinal; 3, cerebro-spinal, and 4, cerebro-cardiac.

The irritant poisons include many which are also corrosive in their action, causing disintegration of the parts with which they come in contact. The pure irritants exert no such chemical action, and are much slower in the development of symptoms. They cause irritation and inflammation of the parts to which they are applied, with violent vomiting and purging, intense pain, and well-marked effects on the nervous system. These symptoms occur after a greater or less interval, according to the nature of the particular poison. The pain, which is usually of an intense burning character, is, unlike that due to colic, much increased by pressure. Septic irritants produce additional symptoms of a character known as typhoidal.

The neurotic poisons act chiefly on the brain, cord, and nerves; occasionally the symptoms manifested partake more or less of the character of irritant poisoning. Those acting chiefly on the brain, producing stupor and insensibility, preceded by fulness of the head, vertigo, impaired vision, delirium, etc., belong to the cerebral; those affecting chiefly the cord producing tetanic or clonic convulsions, to the spinal; those producing symptoms referable to the brain and cord, to the cerebro-spinal; and those affecting the brain and heart, to the cerebro-cardiac class.

Action.—The action of poisons may be local, remote, or both. Local action is physical and chemical, and is manifested by inflammation, corrosion, and direct effect upon the nerves, whereby the functions of organs are impaired or destroyed. If the chemical affinity of the poison for the tissues at the point of application be not great, the result is irritation and inflammation; if, however, the affinity be great, the action is most intense, and we have actual corrosion. Remote action depends upon absorption into, and transportation by, the blood to the various organs which may be affected. Thus, for instance, digitalis affects the heart, strychnine the cord, and opium the brain. In any case of acute fatal poisoning, death is the result of the remote action of the poison, which may or may not have a local action.

The ordinary action of poisons may be modified by the size of the dose, by the chemical combination of the substance, by the state of aggregation or admixture, by the condition or absorptive power of the part or membrane to which it is applied, by the condition of the patient, by habit, and by idiosyncrasy. The young and old are more susceptible, as a rule, than the middle-aged; women more than men; and fasting more than well-fed persons. Disease also may render the subject less susceptible, or, on the other hand, may facilitate the action of the poison. Habit diminishes the effect of many poisons, so that a much larger dose is required for the manifestation of symptoms than would be for persons not so habituated. Idiosyncrasy is a peculiar condition of the system which enables harmless substances to produce violent symptoms similar to those of irritant poisons. Thus many persons are unable to eat certain articles of food, even unknowingly—such as shell-fish, fish, strawberries, some kinds of meat, butter, honey, and other things. In the same way, many persons are seriously affected by small medicinal doses of opium, strychnine, arsenic, and other pharmaceutical preparations. A second form of idiosyncrasy is a tolerance for exceptionally large doses of poison by persons in no way protected by the influence of habit.

Absorption.—In order to produce poisonous symptoms, the presence of a certain amount of poison in the blood is usually necessary, and the amount required depends upon the rapidity of absorption and of elimination. A certain amount of any poison in the blood is incapable of producing any symptoms. Beyond this is that amount which is capable of producing characteristic symptoms—the poisonous dose; then that amount capable of destroying life—the minimum fatal dose; and beyond this up to a certain point, the action is increased in violence and rapidity. The poisonous and minimum fatal doses are relatively large if absorption is slow and elimination rapid, and small if the latter conditions are reversed. The rapidity of absorption depends greatly upon the physical properties of the poison; liquids are more rapidly absorbable than solids, soluble solids more than insoluble, and gases more than liquids or solids. Some insoluble solids may be rendered soluble, and hence more absorbable, by the action of the juices of the stomach and intestines.

Poisons may be taken into the system directly through the blood, as in absorption from wounds or injection into blood-vessels; they may be absorbed through the skin or from the cellular membrane, from inflamed serous surfaces, and from all mucous membranes. Absorption directly into the blood from wounds occurs with great rapidity. Through healthy skin covered with cuticle, absorption is very slow, and in small amount. It is increased by rubbing and by the addition of fatty substances or solvents of the poisons. Gaseous substances are more absorbable than watery solutions, particularly if the latter are warm or hot. On the other hand, absorption from a diseased skin is very rapid, and many fatal cases have been noted from the application of washes, ointments, and dressings to diseased surfaces.

Mucous surfaces absorb poisons in the following order of rapidity: 1, lungs; 2, stomach; 3, intestines; 4, mouth; 5, nose; 6, eyes; 7, tear passages; 8, rectum; 9, vagina; 10, uterus; 11, bladder; 12, prepuce. The mucous surfaces of the lungs and air-passages absorb poisons with great rapidity, and particularly those in the form of gas or dust. The lining membrane of the stomach and intestines is usually the absorbent surface in ordinary cases of poisoning. Fulness of these organs retards, and emptiness favors, absorption. Certain poisons which are rapidly fatal when introduced into the circulation (snake-poisons, curare, etc.), are quite harmless in a full stomach, and indeed are absorbed only in small amount when that organ is empty.

Concerning the absorbent power of other mucous membranes, it is only necessary to remark that all are efficient, though in a somewhat varying degree. On account of the absorption of poisons by the mucous membranes of the intestines and bladder, it is sometimes necessary in treatment to administer cathartics, or to catheterize, in order to prevent the reabsorption of substances which are undergoing elimination from the system by the saliva, the juices of the stomach, pancreas, and intestines, the bile, or the urine.

Elimination.—As soon as absorption begins, the substance is diffused through the whole body by the circulation, and at the same time the process of elimination is begun. Coincident with this is still a third process, that of deposition in the various tissues of the body, from which, however, the poison is eventually eliminated, unless death intervenes. Deposition goes on chiefly in the liver, kidneys, spleen, brain, and heart. The effect of a poison depends upon the relative rapidity of absorption and elimination, and these processes go on with greater or less rapidity according to the nature of the substance. If elimination proceeds as rapidly as absorption, fatal results do not occur; but with a slower elimination the poison will accumulate in the system, and, provided a sufficiently large amount has been administered, will destroy life. Elimination is influenced by the chemical affinity of the poison for the constituents of the blood or of the tissues of the affected organs. If this affinity is great the process is slow; if weak, the process is very rapid.

Gaseous and volatile poisons are excreted chiefly by the lungs; others chiefly by the kidneys, though all secretions of the body play a more or less important part in the process. Certain poisons appear to elect particular secretions, though the urine acts in most cases as the most important channel of elimination. Thus mercury affects the salivary glands, arsenic and antimony the mucous and serous membranes, opium and carbolic acid the milk, and many metallic poisons the bile.

Diagnosis of Poisoning.—The diagnosis of the administration of a poison is based on the symptoms and their course, the detection of poison in articles of food and drink or in the ejecta and excreta, on the post-mortem appearances, and on the detection of the suspected substance in the organs of the deceased. The symptoms are usually of sudden onset, in a person previously in good health, soon after eating or drinking. If several persons are affected at the same time, there is commonly a marked similarity in the symptoms. Where the poison is administered to a sick person, the diagnosis is rendered more difficult on account of symptoms already present, which may appear to be modified or exaggerated, and the phenomena of poisoning may seem to be only the natural course of the disease. Too much importance must not be attached to the fact of recent eating or drinking, since a poison may be inhaled, injected, or applied externally. The diagnosis of the particular kind of poison involved is of great importance for the determination of the treatment to be pursued, and it is therefore essential that the medical attendant should know, if possible, the exact course of the symptoms from their first appearance, the previous history of the patient, and the exact nature of any medicines which may have been administered. Owing to the similarity of symptoms of particular diseases to those produced by certain poisons, one must often exercise great care in making a differential diagnosis. The physician is often aided in forming an opinion by the moral aspect of the case.

Acute irritant poisoning may be suspected when violent purging and vomiting, accompanied by pain in the region of the stomach or complete prostration, occur in a person without some assignable natural cause. Acute neurotic poisoning manifests itself by more or less sudden symptoms referable to the nervous system, such as stupor, insensibility, delirium, or convulsions. Chronic poisoning is more difficult of diagnosis than acute or subacute, on account of the less marked character of the symptoms, which are often, or indeed usually, ascribable to natural causes.

In making a diagnosis in a case of suspected poisoning it is to be borne in mind that symptoms may be delayed by fulness of the stomach, sleep, or intoxication, or may be modified or intensified by disease or debility. Among the diseases which may be confounded with irritant poisoning may be mentioned cholera asiatica, cholera morbus, gastritis, enteritis, gastro-enteritis, colic, peritonitis, intussusception, and dysentery; among those which may simulate neurotic poisoning are apoplexy, sunstroke, uræmia, septicæmia, epilepsy, tetanus, diseases of the brain and of the heart, pulmonary embolism, cerebro-spinal meningitis, rupture of the stomach or gall-bladder, typhoid fever, and coma of various origin.

Of very great importance in the diagnosis and subsequent treatment of poisoning, is the detection of the substance in the remains of food or drink, or in the vomitus; but as it is possible, in any case of criminal poisoning, that these substances may have been removed and others substituted, or in cases of feigned poisoning, that a poison may be introduced into the food-remains or vomited matters, reliance cannot always be placed upon this proof. But the detection of the poison in the urine of the patient establishes the diagnosis beyond any doubt. Yet, at the same time, it must be remembered that the non-detection in that fluid does not by any means prove its non-existence in the body.

The treatment in cases of poisoning depends altogether upon the nature of the particular substance involved. The first indication, except where corrosives or poisons administered otherwise than by the mouth are involved, is evacuation of the stomach and administration of antidotes, stimulants, etc. (See special poisons under their appropriate heads. See also Antidotes.)

Post-mortem Indications.—It frequently happens, in cases of suspected poisoning, that an autopsy is all that is necessary to clearly establish the cause of death, particularly in cases of sudden death, which to the uneducated mind are usually associated with suspicious circumstances. The popular belief in poison as an agent of sudden death is doubtless, in great part, due to works of fiction and the stage, where the interval occurring between the swallowing of the poison and the termination of life is so short that the two events are almost simultaneous. As a matter of fact, sudden death is much more likely to be due to disease than to poison, and, indeed, the only poison which approaches heart-disease and apoplexy in rapidity of fatal effect is anhydrous prussic acid, a poison not easily obtainable. But, in consequence of the popular tendency to associate the two ideas, innocent persons are frequently suspected or accused of a heinous crime, which may be easily disproved by the appearances on section. On the other hand, with perhaps equal or greater frequency, the autopsy serves to direct suspicion or to strengthen it in cases of poisoning which have resembled disease. But it not seldom fails to throw any light whatever upon the question of the cause of death, and then a chemical examination may be required.

The external appearances indicative of poison are very few, and of no great value. Evidences of corrosive action are sometimes furnished by the skin and clothing. The presence of certain poisons may be betrayed by their odors, and of others by stains. There is nothing characteristic to be observed from the attitude of the body, rate of cooling or of decomposition, or expression of the countenance. The rigidity is usually more marked and

longer continued in death from strychnine, and is often diagnostic of this poison; in other cases no great difference is to be observed. The internal appearances vary according to the poison; they may be absent, or so slight as not to attract attention in cases of death by neurotics, or they may be very marked and characteristic where irritants, and particularly corrosives, have been employed. The chemical and physical properties of the blood sometimes undergo considerable changes; it is darkened by chloroform, ether, carbonic acid, sulphuretted hydrogen, and other gases, and by prussic acid and cyanides, oxalic acid, etc.; by morphine, strychnine, and some others, it is both darkened and rendered more fluid. The greater number of mineral poisons have no effect on the blood. The blood-vessels of the brain are sometimes observed to be engorged in narcotic poisoning, but this appearance may be very slight or entirely wanting. The principal post-mortem appearances due to poison are to be found in the alimentary canal and abdominal viscera. Corrosion of any part of the alimentary canal, softening of the mucous membrane, which is changed in color and easily detached, and evidence of intense inflammation or perforation, are diagnostic of corrosive acids or alkalies, etc. In irritant poisoning the stomach and intestines show signs of inflammation of a more or less intense character, and sometimes ulceration and perforation, sometimes thickening of the walls, or even thickening and softening. The changes produced in other organs are chiefly engorgement and fatty degeneration; the latter occurs sometimes with surprising rapidity in the liver in poisoning by arsenic and phosphorus.

The post-mortem appearances in any case of suspected poisoning will be but imperfect evidence of the presence or results of poison, unless it is possible to distinguish them without doubt from analogous appearances which may be the result of disease. Otherwise the proof of poisoning must rest on the detection of the poison in the body, or on outside evidence. The changes which may be referable to disease or to the action of irritant poisons as well, are softening, thickening, reddening, ulceration, and perforation. Softening of the walls of the stomach may be due to poison, to disease, or to post-mortem digestion. If due to poison similar changes are usually to be found in the mouth and œsophagus; if to disease or post-mortem digestion, these additional changes are wanting. Reddening may be due to poisoning or to gastritis, gastro-enteritis, gravitation, or to contact with the liver or spleen. But these appearances could hardly be mistaken by one accustomed to post-mortem examinations; the redness of poisoning is usually accompanied by some peculiarity of appearance which renders it readily distinguishable. Ulceration is more commonly referable to disease than to poison. When due to the former the accompanying redness is confined to the immediate locality, whereas in poisoning it is more or less widely diffused. There is also a considerable difference in the symptoms. Care must be taken not to confound ulceration, which is a vital process, with corrosion, which is chemical. Perforation of any part of the alimentary canal is, like ulceration, of more common occurrence in disease than in poisoning. When due to disease, perforation of the stomach is accompanied by little if any vomiting and no purging, and death is due to peritonitis. The aperture is due to ulceration and not to corrosion, and is usually small in size, and with smooth, regular edges, instead of large, rough, and irregular. Perforation from post-mortem digestion is very rare; it may be suspected from the fact that there has been no peritonitis, nor any symptoms before death to indicate such a severe process. Perforations of the œsophagus and intestines are commonly due to ulceration from the presence of a foreign body, and in such cases the latter is usually discoverable. The intestinal wall is frequently perforated in disease, as, for instance, in typhoid fever.

Chemical Examination.—When a chemical analysis of the body is deemed necessary, the greatest precautions must be observed in performing the autopsy, and in the preservation of organs and fluids. The stomach should be ligatured at both ends before removal. On its being opened the contents should be received in a clean glass or porcelain vessel, and their quantity, color, odor, reaction, and consistency, and the presence of any unusual substances should be noted; the intestines should be treated in like manner. Each organ, on removal, should be placed in a clean vessel by itself, sealed with a private seal, and labelled. Any suspicious vials or powders, and all remnants of food, vomitus, urine, or other substances connected with the case should be sealed at the same time, and delivered to the chemist. In case of exhumed bodies, where decomposition has proceeded so far that the coffin is no longer entire, it is often advisable to take, in addition, a sample of earth from above and below the receptacle. On the delivery of the organs, *et cetera*, to the chemist, it is well to give also a more or less complete history of the case, in order that he may have an idea as to the nature of the poison for which he has to search. From the symptoms and post-mortem appearances it is frequently possible to cut the work of chemical analysis down to a minimum. Failure to detect a poison in the body is by no means conclusive that death has been caused naturally, for there are many poisons which cannot be isolated. The fatal dose of many is so very small that, even if not eliminated in great part before death, its distribution over the system renders it impossible, with our as yet imperfect means, to be isolated. In such cases the proof depends on symptoms and other attendant circumstances. Nor is the presence of poison in the dead body proof that it has caused death, for it is conceivable that poisonous substances may be introduced into the body after death has already occurred, or may have been used as preservatives. But the discovery of the poison in the liver and other viscera, and particularly in the urine, indicates ante-mortem administration beyond reasonable doubt. In many cases where death is the result of chronic poisoning, it is impossible to detect any of the substance, which, having performed its work, has been entirely eliminated from the system. Volatile poisons also may be lost within a very short interval after death, and others may be decomposed or oxidized in the living body. In most cases the ability to detect the poison depends upon the length of time which has elapsed after death, upon the interval between the first manifestation of symptoms and dissolution, upon the amount taken, and upon the amount remaining in the stomach and other organs when death occurs, for reasons which have been already given.

Before proceeding to a chemical analysis, a careful examination of the stomach with the aid of a magnifying glass should be made. Such inspection may reveal crystals or powders admitting of ready examination, or particles of vegetable matter may be detected which may be accurately identified from their botanical characteristics with the aid of the microscope. The organs subjected to analysis should be accurately weighed, and any peculiarities observed must be noted. It is best to divide the organs into several portions: one for preservation, one for volatile substances; one for alkaloids, etc.; one for metallic substances, and one for special poisons. The reagents and chemical apparatus used in an investigation must be free from any impurities. The work must be carried on with great precautions, and without assistance except such as is absolutely necessary, for the chemist must be prepared to swear to the identity of the organs, and to the impossibility of any tampering with his work on the part of others.

The methods of analysis to be pursued vary with the nature of the poison. Many substances require special processes for themselves alone, while others may be grouped together under a single process. It is best to look first for volatile substances which are easily lost with keeping, such as chloroform, ammonia, volatile acids, alcohol, ethereal oils, etc. The substance suspected of containing a volatile poison is rubbed up with sufficient distilled water, made acid or alkaline according to the substance sought for, and distilled; the distillate is then further examined by special tests.

The analysis for metallic compounds requires that the organic matter of the examined substance shall be de-

stroyed, since otherwise it would interfere with the characteristic reactions. For this purpose the substance is heated in an open dish, or glass flask, with chemically pure hydrochloric acid and potassic chlorate, the latter being added a little at a time until the color of the resulting liquid remains straw-yellow for half an hour after the last addition. The excess of chlorine is then driven off by prolonged heating over the water bath, or by the passage of a stream of carbonic acid through the liquid, which is then filtered and subjected to the regular process of qualitative analysis.

The analysis for alkaloids, glucosides, etc., is one which requires great care and delicacy of manipulation. The amount present in any one case is usually very small and widely distributed, and it is, therefore, not at all surprising that an analysis for this class of poisons will often yield negative results even in the best of hands, when the administration of the poison may be proved absolutely. The method of Dragendorff for this class is the one most favorably regarded. This process is briefly as follows: The tissues are cut up small and extracted with acidulated water for several hours at 40° to 50° C., strained through cloth, and filtered. The filtrate is evaporated to beginning syrupy consistence, mixed with three or four volumes of alcohol, and allowed to stand twenty four hours. It is then filtered, the alcohol driven off by evaporation, and the residue transferred to a stoppered flask after being cooled and filtered. The fluid is next shaken in the flask with freshly rectified naphtha, and allowed to stand until the two fluids separate into two layers. The naphtha is then decanted, and the process repeated as long as a portion of the naphtha decanted each time leaves any residue on evaporation. The naphtha removes piperine, picric acid, camphor, and similar substances, a constituent of the black hellebore, ethereal oils, capsicin, carbolic acid, and decomposition products of aconite. The fluid is next shaken with benzol, which removes caffein, cantharidin, santonin, caryophyllin, cubebin, aloetin, digitalin, colchicine, chrysammic acid, picric acid, and colocynthin. It is next shaken with chloroform, which removes cinchonine, theobromine, papaverine, narceine, picrotoxin, helleborein, digitalein, saponin, and jervine. It is then shaken with naphtha, which removes the excess of chloroform, made alkaline with ammonia, and shaken again with naphtha, which removes strychnine, quinine, sabadilline, conhydrine, brucine, veratrine, emetine, coniine, lobeline, nicotine, aniline, and trimethylamine. Benzol removes from the alkaline fluid atropine, hyoscyamine, strychnine, brucine, physostigmine, quinine, cinchonine, narcotine, codeine, sabadilline, thebaine, brucine, veratrine, sabatrine, delphinine, nepaline, aconitine, napelline, and emetine. Chloroform is then used to remove morphine, papaverine, and narceine, and amyl alcohol for morphine and solanine. The fluid is then evaporated with glass powder and extracted with chloroform, which removes curarine. These separate extracts are evaporated each in several watch-glasses, and the residues subjected to chemical and physiological tests. *Charles Harrington.*

POISONS, ABSORPTION AND DISTRIBUTION OF, IN BOTH ACUTE AND CHRONIC CASES. All poisons are absorbed. They may enter the body by various channels, but sooner or later they find their way by osmosis into the circulating blood, and are then distributed in greater or less quantity throughout the body. Toxic action is directly dependent on the absorption of the poison, and the extent of action is in direct proportion to the rate of absorption. A substance in itself insoluble and indiffusible, or incapable of being rendered soluble and diffusible by the juices of the body, is incapable of being absorbed, and hence cannot be a poison.

The fact of absorption cannot now be questioned. All poisons capable of detection by chemical or other methods are found after death in the blood itself, and in parts of the body remote from the point of introduction; and this is true whether the poison has been introduced into the body through the mouth or rectum, through the lungs by inhalation in the form of vapor, by hypodermic injection, by contact with an abraded surface, or even through the sound skin.

Circumstances which Modify the Absorption of Poisons.—Obviously, one of the most important circumstances modifying the absorption of a poison is its solubility and diffusibility. Everything else being equal, the greater the solubility and diffusibility of a poison, the more rapid its absorption, and hence the more rapid its manifestation of toxic action. As a rule, the salts of the alkaloids are more soluble than the alkaloids themselves, and hence the toxic action of the former is more rapid than that of the latter. Arsenite of potash is more rapid in its action than arsenious acid; and this is due in great measure to the rapid absorption of the more soluble compound. The action of many chemical antidotes is confined wholly to the conversion of the rapidly soluble form of the poison into a compound either wholly insoluble, or insoluble to such an extent as to delay its absorption, and thus admit of its removal from the body before it has been absorbed in sufficient amount to lead to a fatal result. Thus, in poisoning with oxalic acid the exhibition of lime-water in large quantities leads to the formation of calcium oxalate, a compound comparatively insoluble and hence limited in its toxic action.

Again, the absorption of a poison naturally soluble is increased by introducing it in the form of a solution. Thus arsenious oxide introduced into the stomach dissolved in water, is more rapidly absorbed than when introduced in the form of powder. Further, when dissolved in dilute alkalies, thereby being converted into a new body, it is still more rapidly absorbed, thus introducing another feature into the problem, viz., that of diffusibility. It is here much the same as it is with certain foods; in order to have absorption we must have not only solubility, but also diffusibility. Thus raw egg-albumen, while readily soluble, is of little use as food until by the action of the digestive juices it is converted into *diffusible* products. Arsenious oxide, then, when dissolved in a given volume of water, is rapidly absorbed; but the same equivalent of arsenic introduced in a similar manner, in the form of an alkali arsenite, is still more rapidly absorbed by virtue of its greater diffusibility. Hence, everything else being equal, the more soluble and diffusible the form of the poison, the more rapid is its absorption, and consequently the more vigorous its toxic action.

Again, the nature of the surface to which the poison is applied modifies materially the rate of absorption. This depends mainly on vascularity; the greater the supply of blood, the more rapidly does absorption go on. Hence, the introduction of a poison in the form of vapor into the lungs leads to more rapid absorption than does injection into the intestine; and similarly, the injection of a soluble poison into the intestines or vagina is ordinarily followed by more rapid absorption than when it is introduced into the stomach. While, then, the natural vascularity of an organ or tissue has some modifying influence on the absorption of a poison, the condition of the blood-vessels also exerts some influence. Fulness of the blood-vessels opposes a mechanical obstacle to absorption, and this no doubt explains, in part, why it is that poisons taken on retiring at night are sometimes delayed in their action until the morning, since during sleep the withdrawal of blood from the brain leads to an accumulation in the abdominal organs, and hence retards absorption from the alimentary canal. For a similar reason, poisons taken on a full stomach are much less rapidly absorbed than when the stomach is in a comparatively empty condition. The delayed absorption incident to the former state is, of course, due in part also to the mechanical obstacle afforded by the food itself, the latter keeping the poison for a time away from the stomach-walls. Hence absorption, and consequently toxic action, is most rapid when the poison is taken into an empty stomach, less rapid when taken with food, and still less rapid when taken after a hearty meal.

In considering absorption from the alimentary canal, we have to notice, further, the modifying action of the

digestive juices. Insoluble substances are not directly absorbed, buf many compounds, by the action of the digestive juices, are so altered that their solubility is either increased or diminished, thus modifying their absorption, and hence their toxic action. As examples of the former there are many metallic carbonates, as lead, copper, zinc, and manganese, which, when taken into the stomach, may be changed by the acid of the gastric juice into soluble chlorides, so that what was in itself an insoluble and non-poisonous substance, may be converted into a vigorous poison.

Subsequent Disposition of the Poison.—Once entered into the circulation, there is a two-fold disposition of the poison possible. Either it is deposited for a time in the various tissues and organs of the body, or else it is at once eliminated through some one or more of the various emunctories. Ordinarily, if sufficient time intervenes between the taking of the poison and death, there is a temporary deposition of the poison throughout the body—after which, however, the deposited poison is gradually redissolved and eliminated. Careful study of collected facts further shows that, as a rule, the poison is deposited in the largest amounts in the liver, kidneys, spleen, heart, lungs, muscles, brain, and bones. In other words, these organs and tissues have the power of absorbing and retaining poisons, and furthermore, this absorbing power is not the same for the different organs. Chemical analysis in poison cases, and in experiments on animals where the conditions are known with much more definiteness, clearly testifies to the accuracy of this statement. Further, variation in the conditions under which the poison is taken modifies not only absorption as a whole, as already indicated, but also the absorption by individual organs and tissues. The form of the poison; the character of the dosage, whether small and oft-repeated, or a single large one; the mode of administration, etc., all are liable to exert their own modifying influence on the absorption of the poison by the different organs. A knowledge of such modifying influence must then necessarily be of great value, especially in medico-legal cases; for in time the accumulated facts will serve as data on which to found definite conclusions concerning the form of the poison, the mode of administration, the length of time intervening before death, and many other points of a similar nature, so important in criminal cases.

In this connection, therefore, the results of the quantitative analysis of the various organs and tissues of the body in poison cases are of great importance, for, as they show the distribution of the poison under known conditions, the time may come when it will be possible to draw deductions in unknown cases from the analytical results. During the past few years many data have been collected in this direction, a few of which may be advantageously mentioned.

Carbolic Acid.—A man swallowed fifteen cubic centimetres of an officinal preparation of carbolic acid (100 parts phenol + 10 parts of water), and died in fifteen minutes. With the internal organs Dr. Bischoff[1] obtained the following results:

112	Gm.	of blood	contained	0.0259	Gm.	phenol	= 0.0231	per cent.
1,480	"	liver	"	0.6370	"	"	= 0.0430	"
322	"	kidney	"	0.2010	"	"	= 0.0620	"
508	"	heart-muscle	"	0.1866	"	"	= 0.0367	"
1,445	"	brain	"	0.3140	"	"	= 0.0217	"
12.5	"	urine	"	0.0014	"	"	= 0.0112	"

This case is particularly interesting as showing how rapidly a readily soluble and diffusible substance may be absorbed, and how quickly it may be distributed throughout the body. Further, it is to be seen that the poison was, at the time of death, in position to be eliminated, having entered into the urine.

Oxalic Acid.—An unknown dose of oxalic acid, followed by death in fifteen minutes. The amounts of oxalic acid found by Dr. Bischoff were as follows:

In 2,240	Grams	stomach, intestines, etc.	....	2.280	Grams	oxalic acid.
" 770	"	liver	.....	0.285	Gram	"
" 180	"	heart-blood	.....	0.043	"	"
" 350	"	heart	.....	0.020	"	"
" 290	"	kidney	.....	0.014	"	"
" 40	"	urine	.....	0.007	"	"
" 730	"	brain	.....			

Potassium Cyanide.—An unknown dose of potassium cyanide. The analysis made three days after death.[2]

223	Grams	stomach and contents	contained	0.0692	Gram	HCN.
595	"	intestines	"	0.0186	"	"
122	"	intestines	"	0.0041	"	"
505	"	liver	"	0.0170	"	"
138	"	heart	"	0.0025	"	"
352	"	brain	"	0.0044	"	"
		urine				

Arsenic.—The case of an adult female who lived two days after taking a fatal dose, furnishes the following results, reported by Dr. E. S. Wood.[3]

179	Grams	stomach	contained	0.0442	Gram	arsenic.
6	"	stomach contents	"	0.0097	"	"
490	"	intestines	"	0.1638	"	"
62	"	intestines contents	"	0.0205	"	"
1,237	"	liver	"	0.0497	"	"
149	"	left kidney	"	0.0043	"	"
125	"	right kidney	"	0.0026	"	"
318	"	uterus	"	0.0065	"	"
521	"	brain	"	0.0088	"	"

In all of these cases of poisoning the order of distribution of the poison is much the same as that previously stated, the liver standing first, then the kidneys, heart, lungs, etc. In experimenting on animals, however, where the poison can be variously introduced, it has been noticed that the distribution of the absorbed poison is not always the same. It is easy to see how there might be a decided difference in an acute and chronic case of poisoning, for if elimination of the poison commences at once, it follows that the relative amount of poison contained in the liver and kidneys must necessarily be different in a chronic case than where a single large dose of the poison is taken. Again, it is not difficult to see how the *form* of the poison might modify the rate of absorption and the order of distribution. This latter fact has been clearly indicated by results obtained with arsenic, both in experiments on animals and in poison cases. Thus Scolossuboff,[4] under the impression that the muscular paralysis noticed in the extremities of animals poisoned with arsenic was accompanied by a localization of the poison in the muscles, subjected his hypothesis to the test of experiment, feeding the animals experimented on with a solution of sodium arsenite. The results obtained in this manner were all of a like nature, and in several respects different from all preconceived ideas. Thus, in one experiment with a bull-dog, which had been fed for thirty-four days with the arsenite, the following amounts of absorbed arsenic were found:

100	Grams of	muscle	contained	0.25	milligram	of arsenic	(As).
100	"	liver	"	2.71	milligrams	"	"
100	"	brain	"	8.85	"	"	"
100	"	spinal cord	"	9.33	"	"	"

It is to be noticed in this experiment that the amount of arsenic in the brain is three times as great as in the liver. In another experiment, with a griffin dog, the brain contained, per 100 grams of tissue, double the amount of arsenic contained in the muscles. In every experiment, comparatively large amounts of arsenic were found in the brain, thus giving evidence of a special localization of arsenic in nerve-tissue; but this result was contrary to the experience of all toxicologists in arsenic cases. Scolossuboff gave his results to the world as characteristic of arsenic poisoning in general, without apparently considering that he was experimenting with a *form* of arsenic but seldom used as a poison, and with which toxicologists had had but little practical experience.

In the white oxide of arsenic (As_2O_3), the arsenic of commerce, and the form most commonly used as a poison, we have to deal with a substance but slowly soluble, while in sodium arsenite we have one of the most readily soluble and one of the most easily diffusible of the solid compounds of arsenic. If the amount of arsenic in the brain could be taken as an index of the *form* in which the poison was taken, whether as a soluble or comparatively insoluble compound, it would in many cases of poisoning be a point of great importance. But in order to have the point in question of any practical value, we must be certain, on the one hand, that under no circumstances can the taking of the white oxide of arsenic, either in the form of powder or dissolved in water or other neutral fluids, be attended with accumu-

lation of arsenic in the brain other than in the merest trace; while, on the other hand, the taking of a soluble arsenite should be attended with a proportionally large amount in the brain. It might be argued that in chronic cases of poisoning with arsenious oxide, where the person has for weeks or months been taking small or gradually increasing doses of the oxide, the poison might then accumulate in the brain. Such arguments have been made, but the facts at our disposal tend to show the incorrectness of such a theory. On the other hand, the use of the more soluble arsenite (and doubtless all of the other soluble salts of arsenious and arsenic acids) should be attended with a noticeable deposition of arsenic in the brain. The literature of the subject contains but little definite, the amount of arsenic in the brain being generally expressed as a mere trace or in other equally ambiguous terms; implying, however, in the generality of cases, that when present it was only in very small quantity. But recent data on this point are quite decided. E. Ludwig,[5] of Vienna, writing from a large experience on the distribution of arsenic in the organs and tissues of suicides poisoned with arsenious oxide, and likewise in the organs of dogs poisoned with the same form of arsenic, both in acute and chronic cases, says: "In all experiments it was invariably found that most arsenic was collected in the liver, that in acute cases the kidneys also contained considerable arsenic, while the bones and brain showed but very small quantities of the poison." Ludwig, moreover, states that "in chronic poisoning with arsenic, where death does not result, the poison remains longest in the liver, while from the other organs it is excreted much earlier." Quoting one of his cases, a suicide, an acute case of poisoning with arsenious oxide, the following results are worthy of notice:

1,480	Grams of	liver contained	51.90	milligrams of arsenic (As).		
144	"	kidney	"	7.69	"	"	"
605	"	muscle	"	0.78	"	"	"
1,461	"	brain	"	0.59	"	"	"
		bones	"	only a trace.			

In 1880, the writer,[6] in conjunction with Professor Johnson, reported on two cases of poisoning with arsenious oxide, where the poison was detected and determined in all parts of the body. In one case there was no question whatever as to the form in which the poison was taken, for a mass of the white oxide was found undissolved in the stomach itself. Here there was present in the stomach, liver, and other internal organs, 83.2 grains of the poison, while the brain contained a hardly perceptible trace of arsenic. It would thus appear that the amount of poison taken has but little influence on the amount absorbed by the brain. In this particular instance there was as large an amount to draw upon as is often found in cases of poisoning, yet the quantity contained in the brain could not have been much smaller and been recognizable. The length of time, however, intervening between the taking of the poison and death was probably not long, although there had been time for decided absorption by the liver and other organs. In the second case referred to, where there was decided evidence of chronic poisoning, a somewhat similar result was obtained. In this case there was present in the entire body 5.22 grains of arsenious oxide, most thoroughly and evenly distributed, even to the bones, and yet the brain contained only an unweighable trace of the poison. Again, experiments carried on in the writer's laboratory, on animals, have led to the same result; whenever the animals have been fed with arsenious oxide, the amount of arsenic found in the brain has been extremely minute, while with the soluble arsenite a much larger amount has been found in the brain. At one time it was considered that the presence of arsenic in the brain was proof positive of the ante-mortem character of the poison; that in no case would the poison, introduced into the stomach or rectum after death, find its way by osmosis to so remote a part as the brain. Sutton,[7] however, by experiments conducted on dead animals, finds that arsenic may pass by diffusion quite rapidly even to the brain. Such being the case, the only way to distinguish between ante and post mortem introduction of arsenic would be to determine the amount of poison contained, for example, in the outer portions of the liver, as compared with the percentage amount in the centre of the organ. Guareschi[8] has also reported on the distribution of arsenic in a case of poisoning with arsenious oxide, and he likewise found only traces of the poison in the brain. Many other cases of poisoning with the more insoluble forms of arsenic, in which the distribution of the poison has been studied, lend favor to this view, that arsenic is to be found in the brain in any quantity only when the poison has been taken in a readily soluble form. One case which came under the writer's observation, is particularly important in this connection. A laboring man ate for his dinner a quantity of bean soup; almost immediately after he was seized with the ordinary symptoms of acute arsenic-poisoning, and died in nine hours. The autopsy showed a marked condition of inflammation of the alimentary tract, and a chemical analysis showed 76.0 milligrams of arsenic in the liver, 0.6 milligram in the kidney, while one-half of the entire brain contained only a recognizable trace of the poison. A portion of the soup (125 c.c.) yielded 314.6 milligrams of arsenious sulphide, while the fact that the arsenic was introduced in the form of arsenious oxide was proved by finding in the sediment from the soup an abundance of the octohedral crystals of the oxide. Such a case as this must necessarily carry considerable weight with it. Everything favored the absorption of the arsenic, yet the brain contained only the merest trace. Again, the writer has obtained like results in an acute case of poisoning with Paris green, or acetoarsenite of copper, in which the liver (2.984 grams) was found to contain 12.7 milligrams of arsenic; the kidneys (515 grams), 3.4 milligrams; 735 grams of muscle, 0.9 milligrams, and the brain (1.179 grams) only a slight trace. These results certainly indicate that the relative distribution of the poison may offer some suggestion as to the form in which the poison was administered, and that, with arsenic at least, a comparatively large amount in the brain may be indicative of a readily soluble form of the poison. In this connection, however, there are always other facts to be learned in the distribution of the poison, which may substantiate the indications obtained by analysis of the brain, and at the same time, perhaps, enable us to distinguish between an acute and chronic case of poisoning.

It is a favorite defence in poison cases, particularly with arsenic, morphine, and some other poisons, to claim that the poison found in the body of the deceased came from some hypothetical medicine containing the poison, and which the deceased had long taken, or that the person was habituated to the daily use of the toxic agent. A study of the distribution of arsenic in acute and chronic cases of poisoning shows plainly that many times, with this poison at least, it is quite possible to decide definitely whether the poison has been for a long time in the body, taken in oft-repeated doses, or whether it has been introduced in one or two large doses.

As preliminary to a discussion of this point I will quote two results of my own experience.

(*a*) In this case there was every reason to suppose a case of chronic poisoning with arsenious oxide. The following results were obtained by analysis of the parts a year and a half after burial:

	Weight of Organs.	Weight of Arsenic.	Per cent.
	Grams	Gram	
Stomach and spleen	514	0.05359	0.01040
Kidneys	80	0.00661	0.00825
Liver	590	0.04788	0.00811
One lung and heart	441	0.01454	0.00329
Intestines and uterus	958	0.02582	0.00269
One lung and liquid from thorax	492	0.00583	0.00140
Bladder	73	trace	.....
Brain	477	trace	
Upper arm (left)	665	0.00542	0.00081
Forearm "	288	0.00158	0.00055
Hand "	150	0.00019	0.00012
Lower leg (right)	1,320	0.00864	0.00065
Thigh "	3,360	0.01675	0.00051
Foot "	468	0.00105	0.00022
Thigh-bone "	615	0.00341	0.00056
Transverse section of body above pelvis	1,920	0.00311	0.00156
Muscle and bone from left breast	496	0.00071	0.00091
Abdominal muscle, right side	615	0.00058	0.00058

(*b*) In this case the evidence pointed to acute poisoning with some readily soluble form of arsenic. Following are the results obtained by analysis:

	Arsenic as As_2O_3. Grain.
Stomach and œsophagus*	0.158
Large and small intestines	0.314
Liver (one-half)	0.169
Kidneys	0.029
Heart (one-fourth)	0.028
Lungs and spleen (two-thirds)	0.114
Brain (one-third)	0.025
Diaphragm	0.010
Trachea, larynx, and tongue	0.081

	Weight of Tissue. Grams.	Weight of Arsenic. Grain.	Per cent.
Left arm	1,230	0.006069	0.000495
Right leg	4,650	0.00764	0.000164
Thigh-bone	216	....	....
Transverse section of body at pelvis	4,060	0.01205	0.000296
Muscle from heart (right)	510	0.00635	0.00124
Muscle from back (left)	620	0.02306	0.00371

In (*a*) the total amount of arsenic was 5.26 grains, in (*b*) 3.119 grains; yet it is to be noticed in (*b*) that the brain contained a comparatively large amount of arsenic, while in (*a*) there was to be found only a trace. This fact, if our theories concerning absorption by the brain are correct, would imply the administration of a soluble form of the poison. Further comparison of the two series of analyses shows other noticeable points of difference which point to the same conclusion, and also throw some light on the character (acute or chronic) of the poisoning.

When there has been time for even distribution of the poison, as in chronic cases, there would seem to be no reason why one set of muscles should contain more arsenic than another, aside from such differences as might arise from differences in vascularity, etc. On the other hand, there is every reason for supposing that when death ensues only a few hours or less after the poison has been taken, the distribution might be quite irregular.

The following table shows the distribution of the arsenic through the muscle-tissue in the two cases, calculated to *grains of* As_2O_3 *per pound* of tissue:

	(*a*)	(*b*)
Thigh-bone	0.004	....
Leg	0.033	0.011
Transverse section	0.109	0.021
Arm	0.046	0.034
Muscle from breast	0.063	0.087
Muscle from back	....	0.260
Muscle from abdomen	0.040	...

In (*a*) the results, with the exception of the transverse section, show a fairly close agreement. There is not that gradual increase from nothing in the bone up to a fourth of a grain per pound as seen in (*b*). The irregular distribution of the poison in tissue of the same kind, noticed in (*b*), is certainly indicative of the arsenic having been taken but a short time before death, particularly as there was none whatever found in the bones, which fact would certainly exclude the possibility of chronic poisoning.

Again, in (*b*) the two kidneys yielded only 1.5 milligram of metallic arsenic, while the tongue and adjacent parts (175 grams) gave 4.0 milligrams, and a portion of the muscles (200 grams) gave 5.65 milligrams of metallic arsenic.

Assuming the usual order of distribution, the amount of arsenic in the kidneys in (*b*) would suggest only a proportionally smaller amount in the muscles; and yet in this particular instance the amount of arsenic contained in 620 grams of muscle-tissue is greater than the amount contained in the entire liver and kidneys together. The kidneys, however, are the organs above all others concerned in the elimination of arsenic. Elimination usually commences almost immediately, and yet in this particular case there is but $\frac{23}{1000}$ of a grain of arsenic in the kidneys, while in less than three pounds of muscle-tissue there is contained half a grain of the poison. This fact would necessarily imply that elimination had but just commenced, and that consequently the poison had not been long taken. It might, perhaps, be argued that the proportionally large amount of poison contained in the muscles, as compared with the liver and kidneys, might imply chronic poisoning, but coupled with the peculiar distribution is the entire absence of arsenic from the bones. Ludwig, moreover, states that in "both acute and chronic poisoning with arsenious oxide, most arsenic is invariably found collected in the liver," and that "in chronic poisoning with arsenic, where death does not result, the poison remains longest in the liver, while from the other organs it is excreted much earlier." It is impossible, therefore, to make the results obtained in (*b*) accord with a case of chronic poisoning with arsenious oxide; and further, the amount of poison found in the brain, and the proportionally large amount in certain muscles, would apparently indicate an extremely soluble and diffusible form of arsenic as the toxic agent.

Such results as these certainly favor the belief that it is quite possible to draw definite conclusions as to whether we are dealing with an acute or chronic case of poisoning. Further than that, it is possible, in some cases, to decide even more definitely regarding the time at which the poison was taken prior to death. In this connection, the fact to be considered most closely is the amount of poison contained in the liver, as compared with the amount present in the alimentary canal and in the different organs of the body. When arsenic, for example, is taken into the stomach, absorption by the liver through the portal circulation commences almost immediately; and, as Dr. Geoghegan[9] plainly demonstrated, deposition of arsenic in the liver continues to increase up to about fifteen hours after the poison has been taken, after which it commences to diminish. Dogiel,[10] who has confirmed Geoghegan's results as to the time required for maximum saturation of the liver, says, "a maximum of arsenic in the liver kills the animal." The absolute amount of arsenic involved in maximum saturation of the liver must necessarily vary somewhat in different cases. Barker,[11] from his analysis of portions of the liver of Horatio Sherman, concluded that the entire liver contained nearly five grains of arsenic. In the case of Dennis Hulburt, also analyzed by Professor Barker, the liver contained over seven grains of arsenic, and it would seem as if these amounts must approach near to the maximum. When such large amounts of the poison are found in the liver, it is safe to assume that the poison must have been taken at least fifteen hours before death.

In recent cases of administration of arsenic, it has been claimed by Taylor[12] that the poison may be found in the stomach and intestines, and not in the liver or other organs. This can hardly be correct under ordinary circumstances, since death seldom results so quickly from arsenical poisoning as to prevent the absorption of at least a small trace of the poison by the liver. Dogiel,[10] who has experimented somewhat on the rapidity of absorption by the liver, found that on forcing five hundred milligrams of arsenious oxide dissolved in water, into the stomach of a dog, death resulted in one hour and five minutes. In a second experiment, conducted in the same manner, death resulted in one hour and thirty-eight minutes. In the first case the liver was found to contain 94.5 milligrams of arsenious oxide; in the second case, 137.8 milligrams. Thus, judging from the amount in the liver at the end of an hour, certainly but a few minutes would have been required for the absorption of a detectable quantity of arsenic.

Arsenic having been deposited in the liver or elsewhere, gradually diminishes, and if the person should survive, entirely disappears in from two to three weeks. A case bearing directly on this point came under the writer's notice some time ago. An entire family were taken sick, directly after eating, with all the symptoms of arsenic poisoning; all of them recovered except one, a middle-aged man, who died just two weeks after partaking of the poisoned food. An autopsy was made, the internal organs were delivered to the writer for analysis, together with the various articles of food partaken of by the family at the time of their sickness. A portion of the bread (786

* The internal organs were preserved separately in alcohol, hence the weights of tissue analyzed are not given.

grams) contained 32.7 grains of arsenious oxide, while a piece of cake (166 grams) was found to contain 55.5 grains of arsenious oxide, thus proving the character of the poison.

Analysis of the internal organs gave the following results, showing that at the time of death elimination was nearly, but not quite, complete:

Stomach (305 Grams)	contained	0.10	milligram arsenic (As).
One-third liver (428 Grams)	"	0.20	" "
One kidney (282 Grams)	"	0.15	" "
One-half intestine (487 Grams)	"	0.20	" "
Thigh muscle (389 Grams)	"	0.25	" "
One-half brain (390 Grams)	"	trace	"

Concise experiments on animals, carried out quantitatively, are capable of yielding many instructive results in reference to the relative distribution of a poison under different conditions. The writer has recently conducted a series of experiments with antimony,[13] a few of the results of which may be advantageously given, as confirmatory of some of the preceding statements.

(*a*) *Hypodermic Injection of a Solution of Tartar Emetic.*—0.120 gram of tartar emetic was introduced under the skin (right thigh) of a cat weighing 1,262 grams. The animal died in two hours. Following is the distribution of the poison:

	Total Weight.	Weight of Sb.	Sb. per 100 Grams of Tissue
	Grams.	Milligrams.	Milligrams.
Liver	52.0	6.35	12.21
Brain	27.5	0.60	2.18
Heart and lungs	32.0	0.70	2.18
Kidney	12.0	0.15	1.25
Stomach and intestines	74.0	0.80	1.08
Muscle from back	138.0	1.25	0.90
	335.5	9.85	....

In a second experiment a smaller amount of tartar emetic (0.082 gram) was injected hypodermatically, and instead of being introduced in a single dose, it was divided into three, and injected separately, several hours apart. As a result, the animal lived twenty-two hours after the first dose. The following results show the distribution of the poison:

	Total Weight.	Weight of Sb.	Sb. per 100 Grams of Tissue
	Grams.	Milligrams.	Milligrams.
Kidneys	11.5	0.60	5.21
Liver	63.0	1.50	2.38
Brain	9.0	0.20	2.22
Stomach and intestines	98.0	2.00	2.04
Heart and lungs	17.0	0.25	1.47
Muscle from back	106.0	0.70	0.66
	304.5	5.25	....

The only difference of importance between these two cases is the element of time. As might naturally be expected, therefore, there is a more even distribution of the poison in the second case than in the first. Further, in the second case the kidneys stand first in their content of antimony, the liver contains a proportionally smaller amount—much smaller proportionally than was found in the first case. This is, of course, due to the fact that in the second case the animal had lived long enough to admit of extensive elimination, and, consequently, those parts which had originally contained the most, particularly the liver, had been drawn on to the greatest extent; so that at the time of death the excretory organs, notably the kidneys, were the richest in poison. Quite noticeable in both of these cases is the comparatively large amount of antimony in the brain—which fact would agree with the previous statements regarding absorption by the brain when a readily soluble and diffusible form of poison is used.

(*b*) *Injection of a Solution of Tartar Emetic per Rectum.*—0.24 gram of tartar emetic, dissolved in a little water, was injected into the rectum of a rabbit, in two doses. Death resulted in about twelve hours. Following was the distribution of the poison:

	Total Weight	Weight of Sb.	Sb. per 100 Grams of Tissue.
	Grams.	Milligrams.	Milligrams.
Stomach and small intestines	172	8.89	15.30
Brain	9	0.40	4.40
Rectum and adjoining intestine	18	0.55	3.05
Liver	54	1.60	2.96
Kidneys	13	0.25	1.92
Muscle	100	1.10	1.11
Urine	20	0.20	1.10
Heart and lungs	17	trace	..
	403	12.99	..

Perhaps the most noticeable feature of these results is the comparatively large amount of antimony contained in the stomach and small intestines; a result which, taken in conjunction with other similar ones, would appear to indicate special absorptive action on the part of the epithelial cell of these parts. The amount of antimony in the kidneys, and particularly the amount in the urine, indicates plainly that at the time of death elimination was going on rapidly; but the fact that the percentage content of antimony in the liver was greater than in the kidneys, might perhaps be taken as an indication that absorption was not completed.

(*c*) *Experiment on a Dog with Antimonious Oxide.*—A dog weighing 14.2 kilos received, with his food, 2.073 grams of antimonious oxide, during a period of seventeen days, in doses of from 0.032 to 0.125 gram per day. The dog was then killed by chloroform eighteen hours after the last dose of antimony had been given. The following results show the distribution of the poison:

	Total Weight.	Weight of Sb.	Sb. per 100 Grams of Tissue.
	Grams.	Milligrams.	Milligrams.
Liver	452	23.7	5.24
Lungs	140	1.8	1.28
Muscle (fore-leg)	157	1.2	0.76
Brain	79	0.4	0.50
Muscle (thigh)	200	0.9	0.45
Kidneys	82	0.1	0.12
Heart	117	trace	....
Blood	440	trace	....
	1,667	28.10	...

In this experiment, which may be termed a chronic case of poisoning with an insoluble form of antimony, the relative distribution of the poison is seen to be somewhat different from the preceding cases. First, the brain contains relatively less antimony than in the preceding; secondly, the liver contains a noticeably large amount of the poison, while the kidneys contain only a trace. This latter result would seem to indicate that elimination was going on quite slowly; but analysis of the twenty four hours' urine showed that the amount eliminated by the kidneys in an entire day was considerable. Thus on one day, the entire twenty-four hours' urine contained 13.5 milligrams of metallic antimony; on another day, 22.5 milligrams.

With copper, Ellenberger and Hofmeister have found, by experiments on sheep,[14] that the liver contains the most copper when small doses have been regularly administered, and, further, that this organ retains the metal with the greatest tenacity, they having found it there forty-one days after the last dose. The pancreas was also found to retain the copper with nearly equal tenacity; the kidneys do not contain so much of the poison. Elimination is mainly by the bile. Deposition of copper in the nerve-tissue is quite small, but still smaller in the muscles, though copper is to be found in the muscles after administration of copper salts. Ellenberger and Hofmeister also state that the deposition of copper is proportionally much greater if it is administered in numerous small doses, the cells then having time to absorb it.

With lead, Victor Lehmann [15] has obtained some interesting results. In his experiments the lead was introduced by hypodermic injection in the form of nitrate, the animals used being rabbits. Two of his series of results are given in full.

(*a*) 0.5 gram of lead nitrate introduced at one dose.

(*b*) 0.01 gram of lead nitrate introduced daily, until finally a total of 0.21 gram of the lead salt had been injected.

Distribution of Lead in (*a*).

	Weight of the Organ.	Content of Lead.	Lead per 100 Grams of Tissue.
	Grams.	Milligram.	Milligrams.
Liver	40	0.250	0.625
Kidneys	13	0.625	4.807
Heart	3	0.125	4.166
Lungs	6	0.125	2.083
Intestine	16	0.312	1.953
Muscle	30	0.187	0.625
Bones	7	0.187	2.678
Brain	8	0.062	0.781
Bile	3	0.125	4.166

Distribution of Lead in (*b*).

	Weight of the Organ.	Content of Lead.	Lead per 100 Grams of Tissue.
	Grams.	Milligram.	Milligrams.
Liver	25	0.062	0.250
Kidneys	4	0.125	3.120
Heart	5	0.187	3.750
Lungs	2	0.062	3.125
Intestine	7	0.125	1.785
Muscle	10	0.031	0.312
Bones	3	0.125	4.166
Brain	3	0.125	4.166
Bile	2	0.125	6.250

Very noticeable in both series is the small content of lead in the liver, an organ which, as a rule, contains the largest amount of absorbed poison. The relatively large amount of lead in the bile naturally suggests that the elimination of the metal takes place mainly through this channel, which would account for the small content of metal in the liver. Further, experiments conducted on rabbits show plainly that more lead is excreted in the fæces than in the urine, the lead in the former doubtless coming from the bile poured into the intestines. Quite noticeable also is the large amount of lead in the bones, which amount probably grows larger the longer the lead has time to act.

Naturally, such systematic work as has been done in studying the relative distribution of poisons has been confined mainly to mineral substances, but it is to be hoped that the time will come when there will be a collection of data embracing all poisons capable of detection by chemical means. When such a time does come, it will doubtless be found that we cannot establish any general laws regarding the relative absorption and distribution of poisons as a class, but rather, that each individual poison or group of poisons will show some peculiarity characteristic of itself—which possibility, or rather probability, makes it all the more needful for us to acquire, as speedily as possible, accurate knowledge of the relative absorption and distribution of the individual poisons.

R. H. Chittenden.

[1] Berichte d. Deutsch. Chem. Gesellschaft, 16, 1337. [2] Ibid., 1355.
[3] Wharton and Stillé's Medical Jurisprudence, vol. ii., Poisons, p. 151.
[4] Bulletin de la Société Chimique de Paris, 24, 126.
[5] Anzeiger der k. Akad. d. Wissensch. Wien, xviii., 18.
[6] Amer. Chem. Journal, vol. ii., p. 232. [7] Ibid., vii., p. 75.
[8] Abstract in Journal of the Chem. Soc. of London, 1884, 199.
[9] Taylor's Treatise on Poisons, Amer. Edition, 1875, p. 40.
[10] Pflüger's Archiv für Physiologie, 24, 343.
[11] Report of the Sherman Poisoning Case, American Chemist, 2, 442.
[12] Treatise on Poisons, p. 42.
[13] Chittenden and Blake: Distribution of Antimony in the Organs and Tissues: Studies from the Laboratory of Physiological Chemistry, Yale University, vol. ii., p. 69.
[14] Abstract in Journal Chem. Soc. of London, p. 474, 1884.
[15] Zeitschrift für physiologische Chemie, vi., pp. 12 and 528.

POKE ROOT AND BERRY (*Phytolaccæ, Radix et Bacca*, U. S. Ph.), Scoke, Garget. This plant is a large, succulent, perennial herb, with a very thick, light-colored, fleshy root, and cylindrical racemes of dark-purple, juicy berries. The root at the crown attains to a diameter of several inches, and divides into two or three large branches; it is brown externally, and light-colored within; when dry it is grayish, hard, wrinkled, and inodorous. Taste, sweetish acrid. The stems when young are bland and juicy, and are cut by country people in some localities as a pot-herb. They attain during the summer a height of from one to two metres, are green at first, but reddish later in the season, branch somewhat, are smooth and cylindrical, and hollow when old. The leaves are also large, petioled, alternate, smooth, oblong, and entire. They are said to exhibit phosphorescence in the dark. The flowers are in terminal racemes becoming lateral and extra-axillary by the growth of the stem; regular, perfect, with five sepals, ten stamens, and a ten-celled

Fig. 3021.—Poke Weed; Flower and Section of the same. (Baillon.)

ovary. The fruit is a ten-seeded, longitudinally flattened berry, about a centimetre across.

The root is prepared for the market by being dug in the fall, and cut into short lengths or slices. The berries are gathered when ripe (July, August) and dried in masses. The composition of the root was studied a few years ago by Mr. Edmond Preston, Jr., who found *starch, tannin, gum, sugar, resin, fixed oil*, etc., a volatile acid, and an alkaloid (?) which he calls *phytolaccine*. Claussen obtained from *Phytolacca* seeds a neutral principle for which the same name is proposed. The berries contain an acid, *Phytolaccic acid*, and a beautiful but very fugitive purple-lake color. Upon which of the above the action of the plant depends is not settled—perhaps it is upon neither.

Action and Use.—All parts of the adult plant are active, and cause in sufficient doses vomiting and purging. It has also some narcotic or stupefying power, and in poisonous doses causes, in addition to the intestinal symptoms, convulsions and coma. Death may follow. Its action is slow and protracted. Poke Root has been administered as an emetic. It is also recommended in rheumatism, scrofula, inflamed breasts and testicles, and as a dressing for cancers and indolent ulcers, but is in very little favor in regular practice; enough may be absorbed from washes and ointments to produce its constitutional effects. It is said to be useful as a parasiticide in sycosis, tinea capitis, the itch, etc., but there are doubtless many better drugs for this purpose. Dose of the root as an emetic, say a gram (15 grains; as an "alterative," one-fourth as much.

Allied Plants.—The order is a small one, and includes no species of economic importance.

Allied Drugs.—The American medical flora contains a number of emeto-cathartics of slow and irregular action, which might be compared with this one. See, for example, Hemp, Canadian, Queen's Root, etc.

W. P. Bolles.

POLAND SPRING. *Location*, Androscoggin County, Me.; *Post-office*, South Poland, Androscoggin County, Me.

Access.—By the Grand Trunk Railway of Canada to Lewiston Junction, about twenty-five miles north of Portland, Me., thence by coach to the spring.

Analysis (Professor C. F. Chandler).—One gallon contains

	Grains
Sulphate of potassa	0.1762
Chloride of sodium	0.2656
Carbonate of soda	0.1.573
Carbonate of lime	1.2287
Carbonate of magnesia	0.5.112
Oxide of iron and alumina	traces
Silica	1.1295
Organic and volatile matter	0.3372
Total	3.0759

Therapeutic Properties.—The chief characteristic of this water is its purity, it being almost free from mineral constituents. Yet its great value in chronic diseases of the kidneys, stomach, and bladder, is unquestionable. It resembles several other valuable springs in this respect (Bethesda, Buffalo Lithia), and we take the opportunity again to give it as our opinion, that it is the imbibition of an excess of pure water, together with regulated diet and habits, that conduces to the re-establishment of a physiological balance. (See article "Dietetic Value of Water," by the writer, *Journal of Reconstructives*, N. Y., April, 1886.)

This spring is located in the southwestern portion of Maine, at an elevation of about 800 feet above the sea. The water, flowing eight gallons per minute, issues from a fissure in gneiss rock.

The Poland Spring House is a large hotel, containing the latest improvements for the safety and comfort of its guests. Within a mile's distance are three lakes furnishing boating and fishing, while good roads afford fine driving. The natural attractions of the place, with its convenient distance from the cities of Portland and Boston, have combined to make it a most popular resort.

Geo. B. Fowler.

POLYURIA. Syn.: Hyperuresis, Diabetes insipidus, Diuresis.

Polyuria means simply excessive flow of urine; and some writers have grouped all the varieties of excessive secretion of urine under this caption. More generally, however, the use of the word is restricted to such cases of diuresis or diabetes insipidus as present an excess of the renal secretion without material changes in its chemical composition, thereby excluding all cases of diabetes mellitus, or glycosuria, and those of albuminuria accompanied by increased flow of urine. It is in this restricted sense that I shall use the word at the present time. Cases of persistent or chronic hyperuresis were recognized and accurately described at an early period of medical history, but without any attempt to classify them on a reliable basis. It was in 1670 that Thomas Willis discovered the existence of sugar in the urine of some of the more important cases of chronic hyperuresis; and nearly a century later, Sauvages described the excretion of sweet (saccharine) urine, as a distinct form of disease, under the name of diabetes anglicus; while it was not until near the end of the eighteenth century that Cullen and P. Frank assumed the presence or absence of sugar in the urine as the only basis of classification, calling the first diabetes mellitus and the second diabetes insipidus. This distinction has been maintained, and the means of diagnosis more accurately defined, by all subsequent investigations, until at present diabetes mellitus is classed, pathologically, with the morbid conditions of assimilation and nutrition; while we have only the cases of non-saccharine diabetes to consider under the head of Polyuria.

Etiology.—Cases of chronic hyperuresis have been attributed to a great variety of causes. Those most frequently mentioned are habitual exposure to cold, damp air, or living in rooms with a deficiency of sunlight; injuries affecting the brain and spinal cord, more especially penetrating wounds in the region of the fourth ventricle and medulla oblongata; violent mental emotions and persistent functional diseases of the nervous system, such as hysteria and epilepsy; and large draughts of cold drinks or sudden exposure to cold air immediately following excessive muscular exercise. But many cases are on record that could be traced to no special cause. Age evidently exerts a predisposing influence, as shown by the following statistics: Of 242 recorded cases, 18 were under five years, 32, between five and ten years, 50, between ten and twenty years, 59, between twenty and thirty years; 42, between thirty and forty years; 20, between forty and fifty years; 13, between fifty and sixty years, and 8, between sixty and seventy years; which is equivalent to seventy-five per cent. between the ages of five and forty years. Observations in regard to sex show more than twice as many cases in the male as in the female.

There are not a sufficient number of reliable observations on record to justify any conclusion in regard to hereditary influences in the production of this form of disease. Both clinical observations and numerous experiments on animals point to some morbid condition of certain nerve-tracts in the medulla oblongata and the floor of the fourth ventricle, by which a peculiar excitation of the renal cells is maintained through the communicating branches of the vaso-motor and sympathetic systems of nerves.

Symptoms and Clinical History.—When not the result of direct injuries to the central portions of the nervous system, or of sudden mental emotions, the symptoms of polyuria generally develop slowly and without marked changes, except in the gradually increasing quantity of urine voided and correspondingly increased thirst.

When the flow of urine becomes greatly in excess, the cutaneous surface appears dry and somewhat shrunken, but much less than in diabetes mellitus. There is some paleness of the features, mental despondency, disturbed sleep, unusual weariness from moderate exercise, excessive appetite for food as well as constant thirst, and frequent eructations and flatulence, with constipation of the bowels. In most cases the specific gravity of the urine is diminished in proportion to the increase of its quantity, varying from 1.002 to 1.010, and the fluid is nearly colorless. It gives less acid reaction than natural, and is often neutral or feebly alkaline, and readily undergoes decomposition. When the disease is not caused by, or associated with, injuries or diseases of the brain or spinal cord, it may continue many years, and rarely proves fatal unless from the nature and extent of the complications. Some cases have been observed to present great variations in their progress, the quantity of urine sometimes diminishing to the natural standard, with corresponding improvement in other symptoms, for several weeks, and then increasing again, thus giving the appearance of an intermittent progress. In some cases exacerbations were traceable to periods of unusual mental or nervous excitement, in others to exposure to cold and damp air, and in still others to excesses in eating and drinking.

During the active progress of polyuria the increased quantity of urine consists entirely of water, while the quantity of the other natural constituents voided in the twenty-four hours remains nearly the same as in health.

This explains why the waste of tissues and impairment of the health is so much less in this form of disease than in diabetes mellitus, even when the actual quantity of urine discharged in the twenty-four hours is greater in the former than in the latter. Small quantities of creatinine, inosite, and of hippuric acid have been found in the urine in some cases. The condition of the digestive organs varies much; sometimes the food digests imperfectly, giving rise to acid and gaseous eructations, flatulency, and constipation alternating with diarrhœa. These symptoms, however, appear to depend more directly on the morbid conditions that have caused the polyuria or have existed as complications, than upon the excessive flow of urine.

Prognosis.—The duration of the disease depends almost entirely upon the nature of the causes and complications. Those cases associated with diseases or injuries of the cerebral and spinal centres usually either recover or prove fatal at an early period, while those dependent upon chronic functional disorders may continue many years. R. Willis has left on record a case that continued fifty years, and Neuffer one that ended fatally in four

months. It is generally conceded that permanent recovery from well-marked cases of this disease are rare, unless the cause or causes producing them are removed, or cease to be operative within the first few months. It is only in such cases as are characterized by a large excess of the urea and other products of tissue metamorphosis, coincident with loss of appetite or ability to digest a full quantity of food, that the life of the patient is in danger from exhaustion. Much the larger number of cases terminate fatally from complications or intercurrent diseases.

Diagnosis.—The most reliable and characteristic symptoms of diabetes insipidus, or simple polyuria, are persistent daily discharges of urine above the ordinary maximum of health, of low specific gravity (between 1.004 and 1.010), and destitute of both sugar and albumen; unnatural thirst, increased in direct ratio to the increase in the quantity of urine voided; and a bodily temperature slightly below the natural standard.

Pathological Anatomy.—As simple polyuria generally continues many years, and rarely terminates fatally, except through the intervention of other diseases, but few opportunities are afforded for careful post-mortem examination. In some cases the kidneys have been found slightly enlarged and more vascular than natural, but more often they appeared unaltered on ordinary inspection. Neuffer has related a case in which the "microscope showed the urinary tubules to be much dilated—some deprived of their epithelium, and others filled with epithelial cells in a state of fatty degeneration."[1]

Much the most numerous and important post-mortem appearances have been found in the brain and its appendages. These consist of inflammatory and degenerative changes in the region of the fourth ventricle, and less frequently in the meninges; of gummata and exostoses; and of tumors. Such changes within the cranium are evidently the results of prior constitutional disorders, and are in no sense dependent on the polyuria. Chemical analyses of the blood have shown a moderate increase of the solid constituents in proportion to the water. It may be safely assumed that uncomplicated polyuria does not involve uniform structural changes either in the kidneys or in other parts of the body, but rather such a modification of the renal vaso-motor nerves as to induce and maintain an increased blood-pressure, and consequent increased elimination of water.

Treatment.—In the treatment of this affection, it is of the highest importance to ascertain, from the history of the patient, what accidents, injuries, coincident diseases, or constitutional morbid conditions, hereditary or acquired, may have been influential in developing or perpetuating the disease.

In all cases in which such causative conditions can be traced, their removal when possible, or alleviation when removal cannot be accomplished, should demand our careful and persistent attention. For directly controlling the diuresis permanently, no remedies have been found to be reliable or uniformly successful. Such cases as have come under my care have been most benefited by living in well-ventilated, well-lighted, warm and dry rooms; wearing warm flannel underclothes; taking a warm water bath, followed by rapid light friction with dry flannel, two or three times a week; allowing the free use of milk, whey, or buttermilk for drink instead of water, and allowing so much exercise in the open air daily as the strength would bear without fatigue. I have allowed such quantity and quality of food as the digestive organs of the patient tolerated without provoking gastric distress or much flatulency. For directly lessening the renal blood-pressure through the vaso-motor nerves, I have given either ergotin or the fluid extract of ergot with glycerine three times a day, in such doses as could be borne without any unpleasant effects, and two or three times, at considerable intervals, pilocarpine was given in sufficient doses to induce its characteristic diaphoretic and sialogogue effects. Under the management here suggested I saw two well-marked cases recover after three and four months, and for more than a year no relapse followed—after which they passed from under my observation. Two other cases were much benefited, but were lost from observation by removal. Sidney Ringer has reported favorable results from the use of ergotin, and Trousseau and Handfield Jones speak with equal favor of the efficacy of valerian root given in liberal doses.

The moderate daily application of electricity, with the positive pole to the nape of the neck and the negative alternately over the loins and the epigastrium, has been found palliative in some cases. The iodides, bromides, and a long list of vegetable astringents have been tried, with no permanent benefit. Opium, from its known power to lessen the renal secretion, has been often used, but its direct tendency to constipate the bowels and disorder digestion pretty uniformly causes its abandonment. The maintenance of regular, natural intestinal evacuations and fair cutaneous exhalations, are objects of importance in all cases of this disease. Whether the solution of bromide of arsenic, which has been reported decidedly beneficial in the treatment of diabetes mellitus during the last few years, would prove equally efficacious in diabetes insipidus, is undetermined, as I have had no opportunity to try it, and have seen no reports from others.

But as simple polyuria is, in a vast majority of cases, only a *symptom* of some pre-existing pathological condition, it is far more important to seek out those conditions and apply such appropriate remedies as their nature shall indicate, than to pursue the vain search for some specific for curing the symptom. *N. S. Davis.*

[1] See Ziemssen's Cyclopædia of Prac. Med., vol. xvi., p. 1032.

POMEGRANATE (*Granatum* U. S. Ph.; *Granati Radicis Cortex*, Br. Ph.; *Cortex Granati*, Ph. G.; *Grenadier*, Codex Med.—the Codex recognizes the flowers, fruit, and rind as well as the bark of the root; the others only the latter). This plant, *Punica Granatum* Linn., order *Myrtaceæ* (or *Lythraceæ*), is a fine shrub or small tree with irregular, slender, often spiny branches, rather irregularly arranged; simple, thick, nearly evergreen, lanceolate, entire leaves, and large, handsome, scarlet flowers. These are situated singly or two or three together near the ends of the branches, with thick bell-shaped, colored, five- to seven-lobed calyx, and from five to seven roundish, thin petals situated at the angles of the calyx lobes. Stamens numerous, inserted on the calyx, stigma one, with a remarkably divided inferior ovary. This has two tiers of cells—a lower of three cells with axillary or central placentæ, an upper of about twice as many cells, with parietal placentæ. Ovules very numerous. Fruit, a berry, from five to eight centimetres across, globular or bluntly angular, with the persistent calyx at the apex, and numerous, drupe-like seeds closely packed within its various cells. It has a rich red or brown-orange color externally, while the glistening and translucent seeds within are of a most beautiful pink tint. The rind is firm and leathery, and has a remote resemblance in appearance to a bitter-orange peel. It is odorless, however, and has a bitter astringent taste. The seeds are oblong, variously compressed, about a centimetre in length, and have a refreshing acid taste. Within the juicy pulp of the seed, is an exalbuminous embryo enclosed in a hard, narrow, and long shell. The Pomegranate has been so long under the influence of cultivation that its native land is not exactly known, but is probably Central and Western Asia, where it grows wild in abundance. It is grown, however, either for ornament or its edible fruit, in most warm, temperate, and subtropical lands. A double flowering variety is common as an ornamental shrub. It is almost as large as the oleander. This plant has been known from a remote time; it is repeatedly mentioned in the Old Testament, is found in old Assyrian and Persian sculptures, and was known in Europe twenty centuries ago.

Description of the Root-bark.—"In thin quills or fragments, from two to four inches (5 to 10 centimetres) long, little over one-twenty-fifth of an inch (1 millimetre) thick; outer surface yellowish-gray, free from

lichens; somewhat warty, or longitudinally and reticulately ridged; inner surface smooth, finely striate gray-

Fig. 2022. Pomegranate. Flowering branch, section of flower, fruit, seed, section of latter. (From Baillon.)

ish yellow, indistinctly radiate; inodorous; taste astringent, very slightly bitter" (U. S. Ph.).

Composition.—The flowers contain coloring matter, tannic acid, etc.; the pulp of the seeds *sugar* and fruit

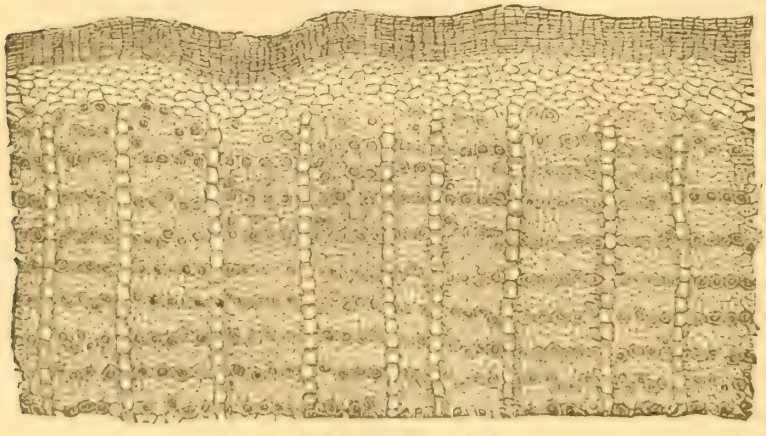

Fig. 2023.—Pomegranate Bark.

acids: the rind of the fruit an abundance of *tannic acid* (28 per cent.); the bark of the root also nearly as much (*punico-tannic acid*), and considerable *mannit*. The important constituent, however, which has been mostly obtained from the bark of the root, is the peculiar, tænicide alkaloid *pelletierine* discovered a few years since by Tanret. It is a liquid, soluble in twenty parts of water, more freely so in the other common pharmacopœial solvents. It forms deliquescent soluble salts with several acids, and a permanent one with tannin. Associated with this are several others: *Methylpelletierine*, *pseudopelletierine*, and *isopelletierine*.

Action and Use.—Pomegranate Root is evidently an astringent of no mean character, in virtue of its large amount of tannin; it has been given for this purpose, although not so much as the rind of the fruit and the flowers. It has also some noxious powers, and is capable of producing vomiting and other digestive disturbances, as well as paralysis. But its principal medicinal value depends upon the poisonous action of the root, and especially of the alkaloid pelletierine, upon tape-worms (*Tænia*, several species).

Administration.—The root may be given in powder or decoction, preferably the latter; of a ten per cent. decoction several wineglasses are to be taken in the course of the day. Since the preparation of the pelletierine and tannin mixture upon a commercial scale, this has deservedly largely superseded the crude doses of the other; it is tasteless and very efficient; from two to four decigrams (3 to 6 grains) may be given. All these preparations should be preceded by the usual fasting, and followed by a cathartic.

Allied Plants.—*Punica* has but one species, and is moreover not closely connected to either of the orders with which it is associated.

Allied Drugs.—The most widely known tænicides are Koosso, Male Fern, Pumpkin Seed, and Pomegranate.

W. P. Bolles.

POMPHOLYX. Under the name of Cheiropompholyx, Hutchinson has described a skin affection similar to that described first by Tilbury Fox as "Dysidrosis" (q.v.). The important question is whether or no the sweat-glands are involved. Robinson thinks they are not, and defines pompholyx as an acute inflammatory affection, characterized by the symmetrical development upon the palms of the hands, and generally also upon the soles of the feet, of deep-seated, clear vesicles, usually grouped, which afterward become opaque, and in a few days disappear by rupture or absorption, leaving a non-inflammatory skin behind.

According to Robinson the disease is a neurosis, the vesicles having an origin similar to those of herpes, especially herpes progenitalis. He holds that the fluid of the vesicles is at first a pure serum, which, coming from the papillary vessels and passing through and between the lower cells of the rete, collects in different situations to form the vesicles. The reaction of the contents of the vesicles in Robinson's case was alkaline.

Jackson has more recently described a case of true dysidrosis, occurring on the face, where the reaction of the fluid contained in the lesions was acid. The conclusion we are inclined to draw from the testimony before us is, that Fox's dysidrosis, Hutchinson's cheiro-pompholyx, and Robinson's pompholyx are the same disease, but that there ex-

ists also a true dysidrosis, of which Jackson's case appears to be an example.

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Arthur Van Harlingen.

PONS VAROLII AND MEDULLA OBLONGATA, DIAGNOSIS OF LOCAL LESIONS IN THE. The pons varolii and medulla oblongata lie upon the base of the brain, between the cerebrum and its crura above, the spinal cord below, and the cerebellum behind. Through

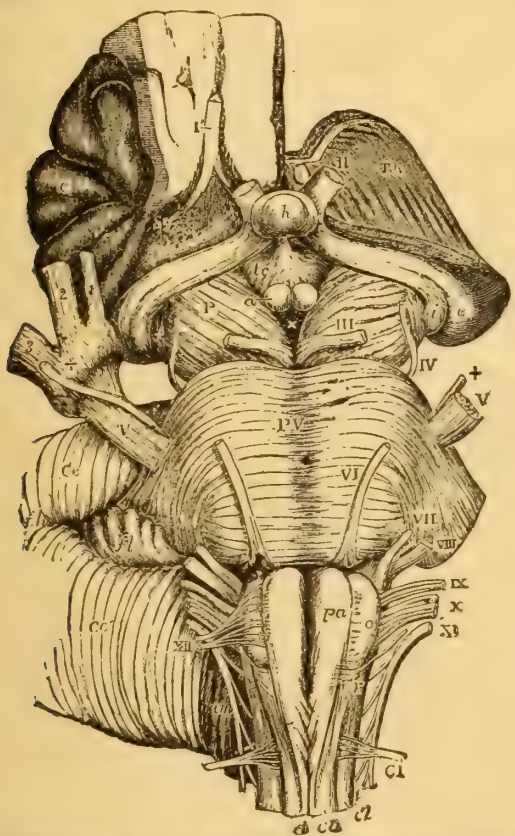

FIG. 3024.—The Base of the Brain and the Cranial Nerves. Pons and Medulla. *I* to *XII*, the cranial nerves; *Th*, optic thalamus; *h*, pituitary body; *tc*, tuber cinerium; *a*, corpora albicantia; *P*, pes pedunculi; *i*, interna', and *e*, external, geniculate body; *PV*, pons varolii; *pa*, anterior pyramid of medulla; *o*, olive; *d*, decussation of anterior pyramids; *ca*, anterior column of spinal cord; *cl*, lateral column of spinal cord; *Ce*, cerebellum; *fl*, flocculus of cerebellum.

them pass important tracts which join these organs with one another, and by means of which motor, sensory, vaso-motor, and trophic impulses are sent from the brain to the body, and from the body to the brain. Diseases in the pons and medulla cause symptoms of wide extent and serious nature, by interfering with the transmission of these impulses. The pons and medulla are not, however, merely organs of transmission. They contain centres of great importance, and preside over numerous functions. In them are located the nuclei of origin of the cranial nerves from the fifth to the twelfth, inclusive, and through them the cranial nerves pass outward from these nuclei to the surface. In them are also situated complex automatic centres, which preside over the acts of combined movement of the eyeballs, deglutition, articulation, respiration, and cardiac inhibition, and which regulate the tone of the entire vaso-motor system, and the secretion of saliva, perspiration, and urine. Disease in the pons and medulla, by affecting these various centres, produces important symptoms, and the complexity of those symptoms is evident from the number of normal functions which will be interfered with in any case of extensive lesion. These functions and their affections must be considered separately.

I. THE TRACTS PASSING THROUGH THE PONS AND MEDULLA.*—These may be studied by the aid of a schematic drawing (Fig. 3025), and by comparing a number of sections made at different levels through the pons and medulla (Figs. 3026 to 3038).

1. *Tracts Connecting the Cerebrum and Cerebellum* (Fig. 3025, 1, 1′, 1″).—From the frontal lobe of each cerebral hemisphere tracts pass downward through the corona radiata, enter the anterior division of the internal capsule, and issue upon the base of the brain in the inner third of the pes pedunculi (Fig. 3024, P). From the parietal, occipital, and temporal (?) lobes of each hemisphere, tracts pass downward through the corona radiata, enter the posterior division of the internal capsule, and issue upon

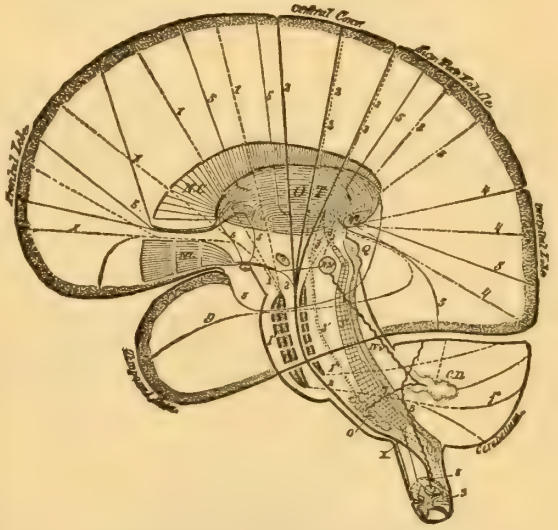

FIG. 3025.—Projection Fibres in the Centrum Ovale and their Terminations. (Modified after Flechsig.) 1, Tract from frontal lobe to pons nuclei, thence to cerebellum; 2, motor tract from central convolutions through capsule, crus, pons, and medulla, to the cord through the decussation; 3, sensory tract from parietal lobe through capsule, tegmentum, and medulla, to posterior columns of cord; 3′, by way of the lemniscus; 3″, by way of formatio reticularis; 4, visual tract from occipital lobe to optic thalamus; 5, optic thalamus radiation to all the lobes; 9, auditory tract from temporal lobe to optic thalamus; O. T., optic thalamus; N. L., lenticular nucleus; N. C., caudate nucleus; R. N., red nucleus of tegmentum; O., olive; C. D., corpus dentatum; 7, tract between O. and C. D.; Q., Corp. quadrigem.

the base of the brain in the outer third of the pes pedunculi (Fig. 3024, P). A section through the crura cerebri at the level of the anterior corpora quadrigemina (Fig. 3026), shows the pes pedunculi (p + p′) separated from the tegmentum by the substantia nigra (*sn*).

The outer and inner thirds of each pes (exclusive of the median fasciculus p^1) is made up of these tracts from the cerebral lobes. After passing through the pes these tracts enter the pons varolii, where they are split up into small bundles by the transverse fibres of the pons. Sections through the pons varolii at various levels (Figs. 3027 to 3032) show that the basal half of the pons consists of longitudinal and transverse bundles of fibres interlaced, and that considerable masses of gray matter, consisting of large polygonal cells, lie between the fibres. It is in these gray masses that the longitudinal bundles under consideration from the cerebral lobes terminate. Hence, in the sections through the lower portion of the pons

* The reader is referred to the article upon Brain, Diagnosis of Local Lesions in the, vol. i., which should be read in this connection.

(Figs. 3031 and 3032) fewer longitudinal bundles are seen than in the upper sections. From the masses of gray matter in the pons, the transverse fibres originate and pass laterally to the cerebellum. The majority of the fibres from one-half of the pons pass to the opposite hemisphere of the cerebellum, and thus cross the median line, where they interlace with those of the other side. The

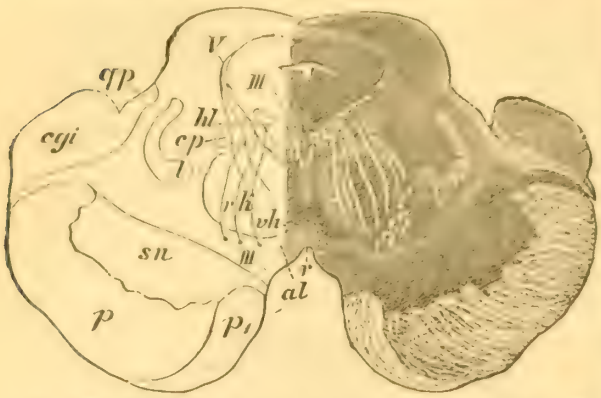

Fig. 3026.—Section through the Crura Cerebri. (Wernicke. × 2.) *p*, Pes pedunculi; p^1, median fasciculus; *sn*, substantia nigra; *cm*, corp. geniculatum internum; *qp*, corp. quadrigem. post.; *l*, lemniscus; *rk*, red nucleus of tegmentum through which pass fibres of oculomotor nerve, *III*, from its nucleus in the gray matter below the aqueduct of Sylvius, to its exit between the crura; *cp*, fibres in the formatio reticularis which have come from the post. commissure; *hl*, posterior longitudinal bundle; *V*, descending root of the trigeminal nerve; *vh*, upper part of the decussation of the superior peduncles of the cerebellum, which end in the *rk*; *r*, raphé; *al*, lenticular loop.

gray masses of the pons are thus interposed in a continuous tract between the cerebrum and cerebellum; each cerebral hemisphere being connected with both cerebellar hemispheres, but to a far greater extent with the opposite hemisphere than with the one upon the same side. Lesions of the frontal, parietal, and occipital lobes, if extensive, are followed by degeneration in the tracts

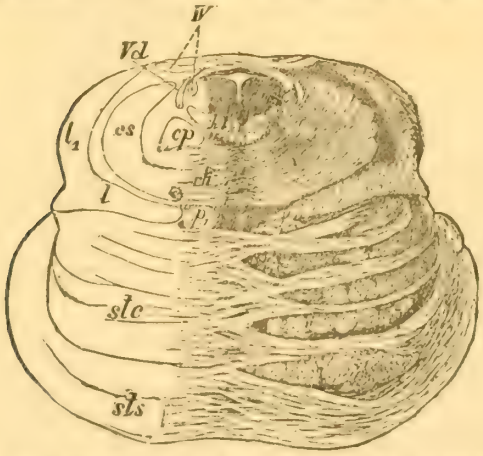

Fig. 3027.—Section through the Pons. (Wernicke, × 2.) *sts* and *stc*, Superficial and deep transverse bundles of fibres intersecting the longitudinal bundles, and terminating in the masses of gray matter of the basal portion; p^1, median fasciculus of the pes; *l*, lemniscus; l^1, lower lemniscus; *rk*, red nucleus of tegmentum; *cs*, superior peduncle of cerebellum, some fibres of which are decussating in the raphé; *cp*, fibres in formatio reticularis, which have come from the posterior commissure; *hl*, post. longitudinal bundle; *Vd*, descending root of the fifth nerve; *IV*, fourth nerve decussating in the valve of Vieussens.

from these lobes to the masses of gray matter in the pons. Congenital absence of the cerebral cortex (porencephalie) results in congenital absence of these tracts. Absence of the cerebellum is attended by absence of the transverse fibres of the pons, which join the cerebellar hemisphere with the gray masses of the pons. Congenital deficiency of one cerebral hemisphere is occasionally attended by atrophy of the opposite cerebellar hemisphere, and vice versa. The function of the tract from the cerebrum to the cerebellum is doubtless to maintain a communication between these organs. But the exact function is unknown, and lesions in the course of these tracts in the pons do not produce any known symptoms.

2. *The Motor Tracts.*—These enter the upper border of

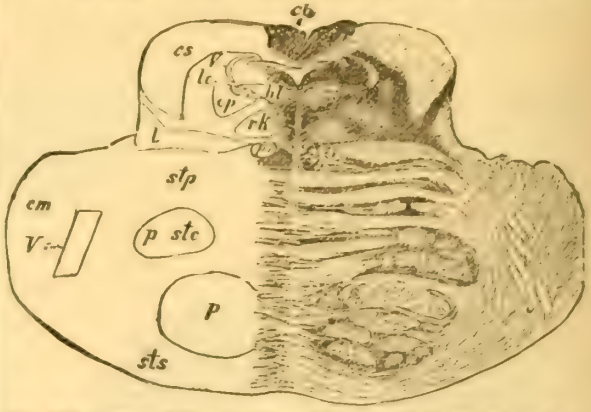

Fig. 3028.—Section through the Pons. (Wernicke, × 2.) *sts*, *stc*, *stp*, Superficial and deep transverse bundles of the pons, intersecting the longitudinal bundles, and terminating in the mass of gray matter of the basal portion; *p*, pyramidal motor tract from the middle third of the pes; p^1, median fasciculus of the pes, here seen to join the lemniscus; *l*, *V*, fifth nerve-root; *cm*, middle peduncle of cerebellum; *cs*, superior peduncle of the cerebellum with *cb*, valve of Vieussens; *rk*, *hl*, *cp*; *V* as in Fig. 3027; *lc*, locus cæruleus.

the pons from the middle third of each pes pedunculi (Fig. 3026), having come from the central convolutions through the corona radiata and anterior part of the posterior division of the internal capsule (Fig. 3025, 2). Each motor tract, at its entrance into the pons, contains fibres whose destination is to the motor centres for the face, arm, and leg of the opposite side. But the centres of the facial nerve lie in the pons varolii (Figs. 3031 and 3032). In its passage through the pons, therefore, the facial division of the motor tract leaves the remainder and crosses the median line. This crossing is made by way of the raphé, fibres leaving the longitudinal bundles in the ventral half of the pons, turning dorsad, entering the raphé, decussating with similar fibres from the opposite side, and then turning laterad to reach the facial nucleus (see Figs. 3031 and 3032). From the facial nucleus the facial nerve passes outward to the side of the pons, having first passed inward and curved around the abducens nucleus in the so-called knee of the facial nerve. The accompanying diagram indicates the course of the motor tract in the pons and medulla. As a result of the division of the motor tract of one side, lesions in the pons produce different forms of paralysis, according to their location. A lesion in the motor tract in the upper third of the pons causes hemiplegia of the side opposite to the lesion (Fig. 3029, lesion at *A*). A lesion in the middle or lower third of the pons causes alternating paralysis, *i.e.*, paralysis of the

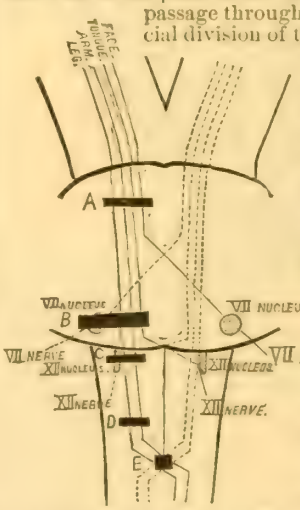

Fig. 3029.—The Motor Tract in Pons and Medulla. Lesion at *A* causes hemiplegia of side opposite to lesion; lesion at *B* causes alternating paralysis; lesion at *C* causes paralysis of tongue on side of lesion and of extremities of opposite side; lesion at *D* causes paralysis of extremities of opposite side; lesion at *E* causes paralysis of extremities of both sides.

face on the side of the lesion, with paralysis of the arm and leg on the opposite side (Fig. 3029, lesion at *B*). In the first case (hemiplegia) the upper branch of the facial nerve is not affected, the patient can close his eye on the paralyzed side, and the facial muscles contract to the faradic electric current. In the second case (alternating paralysis) all branches of the facial nerve are involved, the eye remains open, and the reaction of degeneration develops soon after the lesion occurs. In this case it is usual to find a paralysis of the abducens nerve on the same side as the facial paralysis, in which case the eyeball will be turned in.

The motor fibres to the tongue take a similar course to those to the face, but leave the motor tract at a point in the lower third of the pons. Having reached the hypoglossal nucleus in the medulla they end, but the hypoglossal nerve passes outward, lying in close proximity to the motor tract in the medulla, as shown in the diagram. A lesion in the lower third of the pons or in the medulla, may thus cause paralysis of one side of the tongue and of the opposite arm and leg (Fig. 3029, lesion at *C*). In the medulla the motor tracts pass in the anterior pyramids (see Fig. 3024, *pa*), and before entering the spinal cord undergo partial decussation. A lesion in one pyramid will

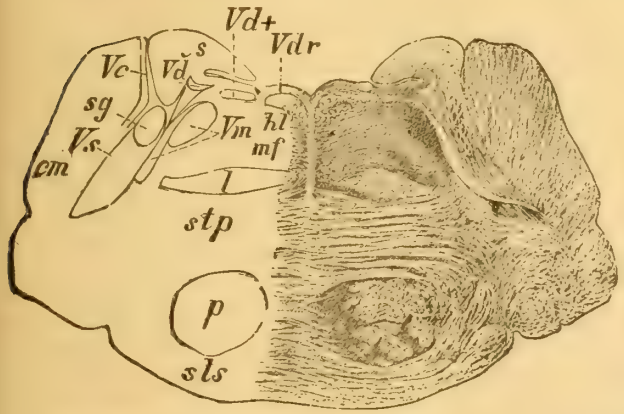

Fig. 3030.—Section through the Pons. (Wernicke, × 2.) *sts*, *stp*, Superficial and deep transverse pons fibres from the cerebellum through *cm*, the middle cerebellar peduncle; *p*, the pyramidal (motor) tract; *l*, lemniscus; *mf*, formatio reticularis; *hl*, post. longitudinal bundle; *Vm*, motor nucleus and root of the trigeminal nerve; *Vs*, sensory root of the trigeminal nerve; *Vc*, cerebellar root of the trigeminal nerve; *Vd*, descending root of the trigeminal nerve (see Figs. 3029, 3028, and 3027); *Vd+*, crossed descending root of trigeminal nerve; *Vdr*, fibres from the raphé to the trigeminal root; *sg*, substantia gelatinosa of *V* root.

cause paralysis of the opposite arm and leg (Fig. 3029, lesion at *D*); but as the two pyramids lie side by side, lesions of the medulla, by affecting both at once, may produce paralysis of both arms and legs; and this is especially the case if the lesion lies so near the spinal cord as to involve the decussation (Fig. 3029, lesion at *E*).

The various forms of paralysis produced when both sides of the pons are involved at once can be ascertained by reference to the diagram.

In all these affections of the motor tract a condition of spastic rigidity may follow the paralysis, and an increase of tendon reflexes is usually observed. In a few cases of pons lesion, however, the tendon reflexes have been lost. The electric condition of the paralyzed muscles in the limbs is normal from the outset, and no rapid atrophy occurs.

The situation of the pyramidal tract is seen in all the figures at *p*. In the upper part of the pons (Figs. 3028 and 3029) its fibres are seen to be split up into small bundles by the transverse pons fibres. In the middle of the pons, however (Fig. 3030), they have collected together, and in the lower part of the pons (Figs. 3031 and 3032) they form a compact tract which continues downward in the anterior pyramid of the medulla (Figs. 3033 to 3036, *p*). At the lowest level of the medulla (Fig. 3036) the pyramidal fibres decussate, and thus pass into the lateral columns of the spinal cord. About one-fifth of the pyramidal fibres do not, however, take part in the decussation, and these continue downward in the anterior median columns of the spinal cord. The ratio of decussating to non-decussating fibres was found by Flechsig to vary greatly, and in one case in sixty no decussation occurs. The relative sizes of one lateral pyramidal tract and of the opposite anterior median column of the spinal cord

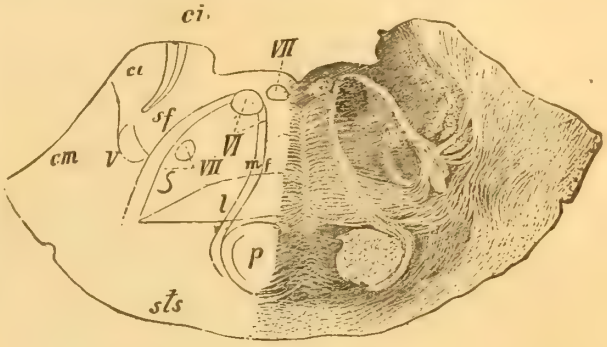

Fig. 3031.

depend wholly upon the extent of the decussation of the pyramids in the medulla.

3. *The Tract of Muscular Sense.*—This is called the lemniscus, or fillet in the pons, and the interolivary tract in the medulla. As it conveys sensations upward we trace it in that direction. It arises from the nuclei gracilis and cuneatus on the dorsal surface of the medulla, in which the columns of Goll and Burdach of the spinal cord end (Figs. 3036 and 3037, *ft* and *fc*). It then crosses the median line, decussating with its fellow of the opposite side in the upper decussation of the medulla (sensory decussation of Meynert; pinniform decussation of Spitzka) (Fig. 3036, *l*, *ft*). The fibres after decussating turn upward, enter the interolivary tract, and pass onward through the medulla beyond the upper level of the olives into the pons (Figs. 3035 and 3034, *l*). Here this tract broadens out, becoming almost ribbon-like in its appearance, and hence has been called the fillet. In the

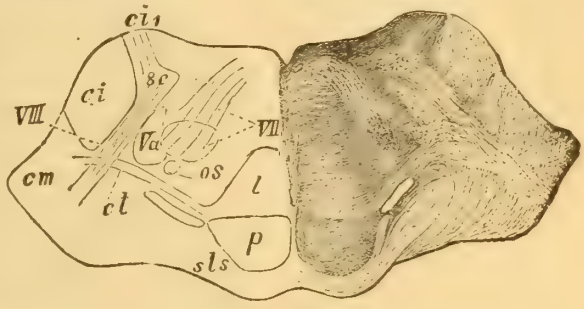

Fig. 3032.

Figs. 3031 and 3032.—Sections through Pons. (Wernicke, × 2.) *sts*, Superficial transverse pons fibres from cerebellum through *cm*, middle cerebellar peduncle; *p*, pyramidal tract; *l*, lemniscus; *mf*, formatio reticularis; *VI*, abducens nucleus from which abducens nerve passes forward, lying near *p*; *VII*, facial nucleus lying deep in *mf*, sending its fibres backward toward the floor of the ventricle (Fig. 3032), where they turn upward (Fig. 3031), and then curve outward, thus forming a bend or knee around the *VI* nucleus; *Va*, ascending root of trigeminal nerve; *ci*, inferior cerebellar peduncle; *VIII*, auditory root; *8c*, external auditory nucleus; *ct*, corpus trapezoides; *os*, superior olive.

pons the fillet lies behind the deep transverse bundles of the pons, and just in front of the formatio reticularis (see Figs. 3028 to 3033, *l*).

As it passes up it receives additional fibres from the superior olive (Fig. 3033, *o*, *s*), but these leave it again at the level of the post. corp. quad. (Fig. 3028, l^1), while the main part of the fillet passes onward in the outer part of the tegmentum of the crus cerebri (Fig. 3026, *l*),

and thence into the posterior part of the internal capsule, whence it radiates to the parietal cortex of the brain.

Sensations of muscular sense being transmitted by this tract, a lesion in it causes ataxia in the limbs of the opposite side. A unilateral ataxia may indicate a lesion in the course of the fillet.

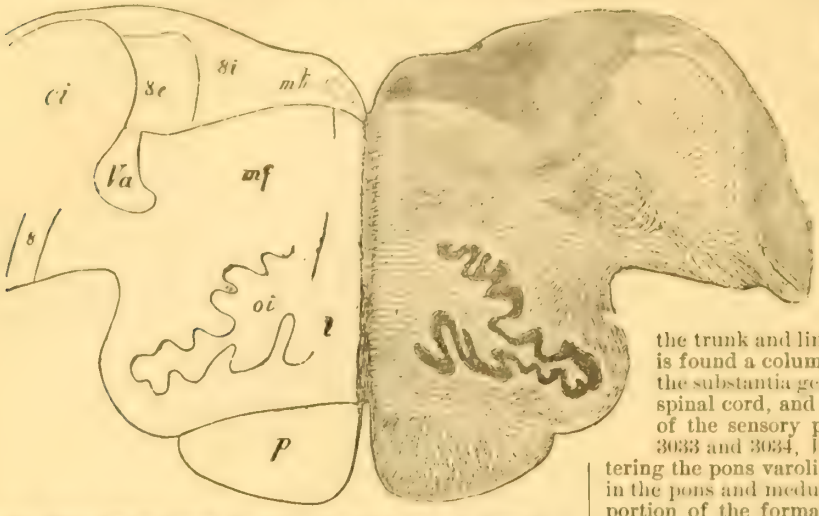

Fig. 3033.—Section through Medulla. (Wernicke, × 4.) *p*, Pyramid; *l*, lemniscus or interolivary tract; *o*, olive; *mf*, formatio reticularis; *Va*, ascending root of trigeminal nerve; 8, auditory root; *8e*, external auditory nucleus; *8i*, internal auditory nucleus; *mk*, upper end of hypoglossal nucleus; *ci*, inferior peduncle of cerebellum.

4. *The Sensory Tract*, which transmits sensations of touch, temperature, and pain through the medulla and pons, is in the formatio reticularis. This portion of the medulla and pons lies just beneath the gray matter of the floor of the fourth ventricle, behind the tracts hitherto described. It is made up of nerve-fibres passing in three directions: *a*, transversely, the commissural fibres of the cranial nerve nuclei; *b*, from the nuclei ventrad, the fibres of the cranial nerve-roots and arciform fibres; *c*, longitudinally, the sensory tract. The longitudinal fibres can be traced from the gray matter and various columns of the spinal cord, through the formatio reticularis to its upper level in the tegmentum of the crus, whence they issue to enter the posterior part of the internal capsule. In the medulla the formatio reticularis of each side is divided into two parts by the line of exit of the nerve-roots of the twelfth (see Fig. 3034). The inner part, near the median line, contains the continuation of the anterior and antero-lateral columns of the spinal cord, and the interolivary tract or lemniscus already described. The outer part contains the sensory tract now under consideration. In the inner two-thirds of this outer part the fibres pass which convey impressions of touch, temperature, and pain from the opposite half of the trunk and limbs. In the outer third of this part is found a column of peculiar structure resembling the substantia gelatinosa of the posterior horn of the spinal cord, and in this column terminate the fibres of the sensory part of the trigeminal nerve (Figs. 3033 and 3034, *Va*), which turn downward after entering the pons varolii, and terminate at different levels in the pons and medulla (see Fig. 3035). Thus the outer portion of the formatio reticularis contains the sensory tract from the face of the same side. It is evident from the diagram, that a lesion which involves one-half of the formatio reticularis in the pons and medulla will produce an alternating anæsthesia, *i.e.*, loss of sensation on one side of the body, and on the other side of the face and head (lesion at *B*, Fig. 3035). Alternating anæsthesia is as characteristic a symptom of lesions of the formatio reticularis of the pons and medulla, as alternating paralysis is of lesions in the motor tract of the pons. In the upper part of the pons the sensory tract from the face crosses the median line, and hence a lesion in the formatio reticularis in the upper third of the pons, or in the crus cerebri, will produce a unilateral anæsthesia (lesion at *A*, Fig. 3035), (see Fig. 3030, *Vdr*, *Vd* +). A lesion involving both halves of the formatio reticularis will produce bilateral sensory symptoms.

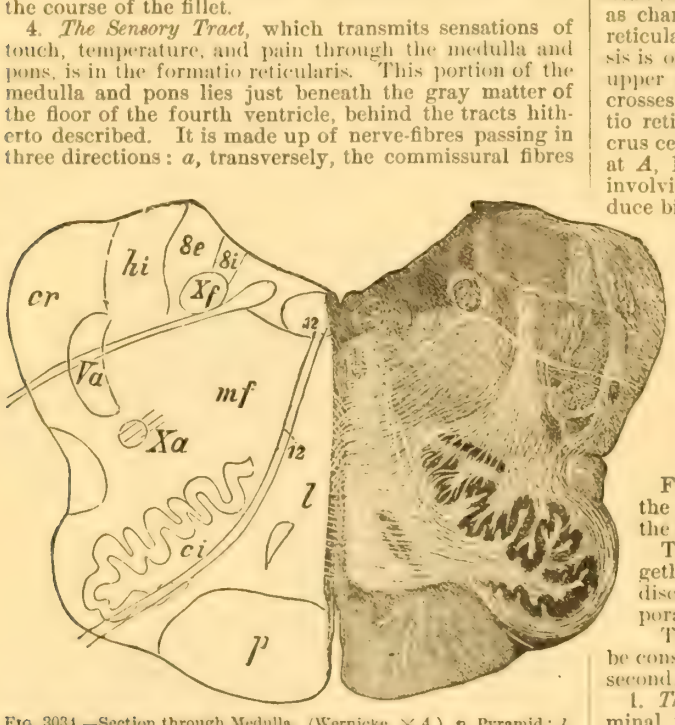

Fig. 3034.—Section through Medulla. (Wernicke, × 4.) *p*, Pyramid; *l*, lemniscus or interolivary tract; *ci*, fibres from the olive which cross the raphe and pass outward and backward to enter the inferior cerebellar peduncle, *cr*; *mf*, formatio reticularis, in which *Xa*, the deep nucleus of the vagus (nucleus ambiguus), lies; *Va*, ascending root of trigeminal nerve; 12, hypoglossal nucleus and root; *Xf*, respiratory bundle around which, in the floor of the ventricle, the vagus nucleus lies, and below which the vagus root issues; *8e* and *8i*, auditory nuclei; *hi*, nucleus cuneatus, from which fibres pass outward and enter *cr*.

It is evident that a lesion of any extent, either in the pons or medulla, will inevitably destroy one or more of these four tracts, and consequently will produce serious symptoms of wide extent and of considerable diversity.

II. The Centres Lying in the Pons and Medulla.—The cranial nerve nuclei lying in the pons and medulla must be briefly enumerated, since lesions affect them. They are located either in the gray matter of the floor of the fourth ventricle, or below this in the formatio reticularis.

Figs. 3038 and 3039 show the relative position of the cranial nerve nuclei in the pons and medulla from the fifth to the twelfth, inclusive.

The third and fourth nerve nuclei and roots, together with the effect of lesions in them, have been discussed in the articles on Brain Lesions in the Corpora Quadrigemina, and on Ophthalmoplegia Externa.

The cranial nerves from the fifth to the twelfth may be considered in two categories: first, the motor nerves; second, the sensory nerves.

1. *The motor nerves* are the motor branch of the trigeminal which supplies the muscles of mastication, the abducens, the facial, the motor portion of the glossopharyngeal, and of the vagus, the spinal accessory, and the hypoglossal.

Lesions which irritate the tracts from the cortical centres to these nuclei, or lesions in their vicinity which cause irritation, may produce spasm of the muscles supplied by them. Thus spasm of the jaw (trismus), with grinding of the teeth, nystagmus, conjugate lateral deviation of the eyes, spasm of the face, spasm of the throat and larynx, and spasm of the tongue may occur from

lesions of an irritating nature. Such are small hæmorrhages, small areas of softening, or small tumors in the pons or medulla. Such lesions must lie in or near the floor of the fourth ventricle, or in the course of the nerve-roots, to produce these spasms. A review of recent literature shows that they are to be regarded as rare symptoms. If such spasms occur alone, without other symptoms, it is difficult to determine the nature of the lesion, or to decide that the spasm is not functional. If they occur in connection with other symptoms of pons or medullary lesion, they are valuable as evidence of the exact position of the disease.

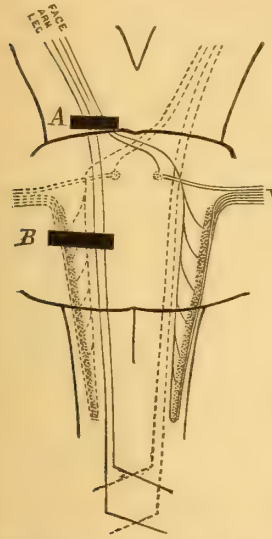

FIG. 3035.—The Course of the Sensory Tract in Pons and Medulla. *A*, Lesion in tegmentum of crus cerebri, or upper quarter of pons, producing hemianæsthesia of the opposite side; *B*, lesion in formatio reticularis of pons or medulla, producing alternating anæsthesia.

Lesions which interrupt the tracts from the cortical centres to the motor nerve nuclei, which destroy those nuclei, or which interfere with the conduction of impulses along the nerve-root and nerve-trunk, will produce paralysis. Paralysis of the muscles of mastication is the rarest form of paralysis. Paralysis of the external rectus muscle, or of the facial muscles and tongue, are very common. Paralysis of deglutition or of the vagus are occasionally met with. It is easy to determine in any case whether the paralysis is due to lesion of the central tracts, or to lesion of the nerve-nuclei. In the first case atrophy does not follow the paralysis, and there is no change in the electric reaction in the muscles. In the second case atrophy occurs soon after paralysis, and is accompanied by a reaction of degeneration. But the latter symptoms are common to lesion of the nerve-root and trunk as well as to lesion of the nucleus, hence other symptoms are necessary to establish a diagnosis of a lesion in the nucleus. When paralysis of the muscles supplied by one cranial nerve occurs alone, the probability is in favor of a peripheral nerve-lesion, *e.g.*, a meningitis or tumor on the base of the brain; and a central lesion can only be thought probable when an implication of other muscles in the domain of other nuclei ensues.

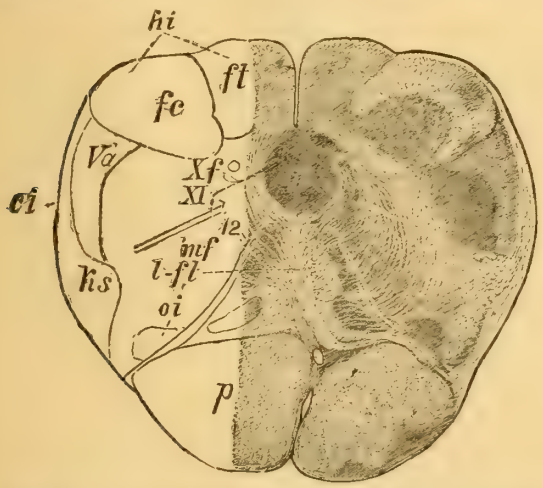

FIG. 3036.—Section through Medulla, Level of Sensory Decussation. (Wernicke. × 4.) *ft*, Nucleus gracilis; *fc*, nucleus cuneatus; from which fibres curve around the central gray, and then decussate and turn upward (cephalad) in the interolivary tract, *l*, *ft*; *Va*, ascending root of the trigeminal nerve; *ci*, inferior peduncle of cerebellum, of which *ks*, direct cerebellar column of the cord, is a part; *Xf*, respiratory bundle; *XI*, medullary nucleus of spinal accessory nerve and its root; 12, hypoglossal nucleus and root; *mf*, formatio reticularis; *oi*, olive.

Paralysis of the external rectus is so common that it requires some attention. It is usually due to a lesion on the base of the brain outside of the pons, involving the sixth nerve. It may be due also to lesion in the pons between the nucleus of the sixth nerve and the exit of the root (see Fig. 3031). In both cases there will be a permanent deviation of the eye inward and an inability to turn it outward, with contraction of the pupil. But abducens paralysis may also be due to a lesion of the abducens nucleus in the pons. In such cases there is the added

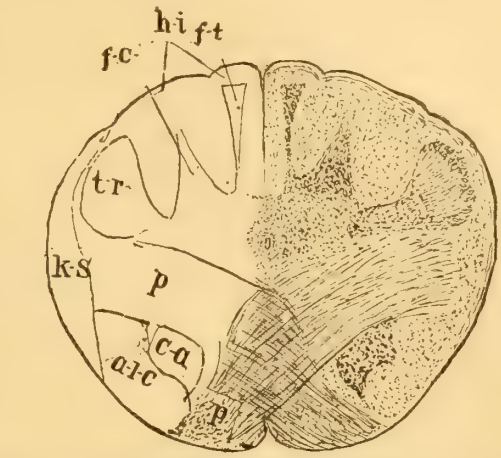

FIG. 3037.—Section through Medulla, Level of Motor Decussation. *ht*, Posterior columns of spinal cord; *ft*, nucleus gracilis in column of Goll; *fc*, nucleus cuneatus in column of Burdach; *tr*, tubercle of Rolando, where posterior horn of spinal cord merges into *Va*, ascending root of *V*; *ks*, direct cerebellar column; *p*, pyramid decussating to reach lateral column; *ca*, ant. cornu of cord; *alc*, antero-lateral column of cord.

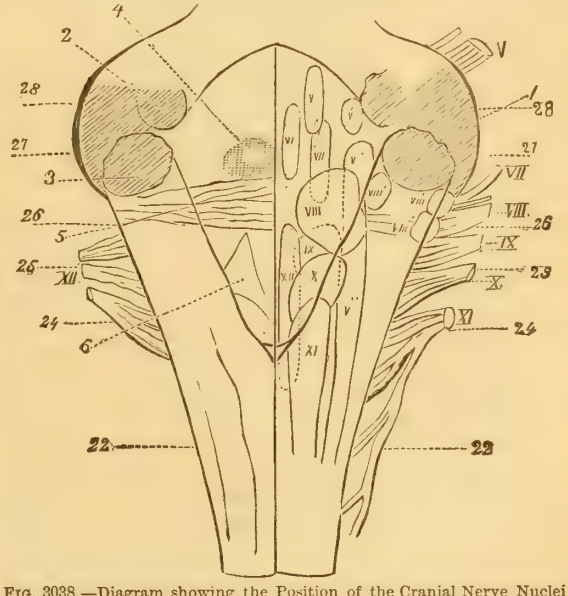

FIG. 3038.—Diagram showing the Position of the Cranial Nerve Nuclei upon the Floor of the Fourth Ventricle (Erb). *v* to *xii* nuclei; *V* to *XII*, cranial nerves; *V.* median of *V*, *V*, motor nucleus of *V″*, ascending root of *V*; *VIII*, inner nucleus of *VIII*; *VIII′*, outer nucleus; *VIII″*, *VIII‴*, lateral nuclei of *VIII*; 27, middle cerebellar peduncle; 3, inferior cerebellar peduncle; 2, superior cerebellar peduncle; 4, eminenter teres; 5, striæ acusticæ; 6, ala cinerea.

symptom of inability to perform conjugate movement of both eyes toward the side of the lesion, and a permanent deviation of both eyes to the opposite side. But this deviation does not prevent the voluntary act of convergence of both eyes to a near point. Lastly, abducens paralysis may be due to lesions in the pons, or between the pons and the cortex, in the course of the tract conveying voluntary impulses from the cortex to the sixth nerve nucleus. Such lesions will interfere with voluntary conjugate movement of both eyes to one side, viz., toward the side whose abducens is paralyzed. But since such a lesion may lie in the pons after the decussation of this tract, or in the cerebrum before its decussation, it cannot be said that the deviation is uniformly either toward or away from the lesion. In this case there is no permanent deviation of the eyes to either side; for the abducens nucleus being uninjured, it maintains the tone of the external rectus muscle, and during rest the eyes are found directed forward. If a lesion in the course of the central tract is of an irritative nature, however, it may cause forced motions of the eyes by sending impulses to the

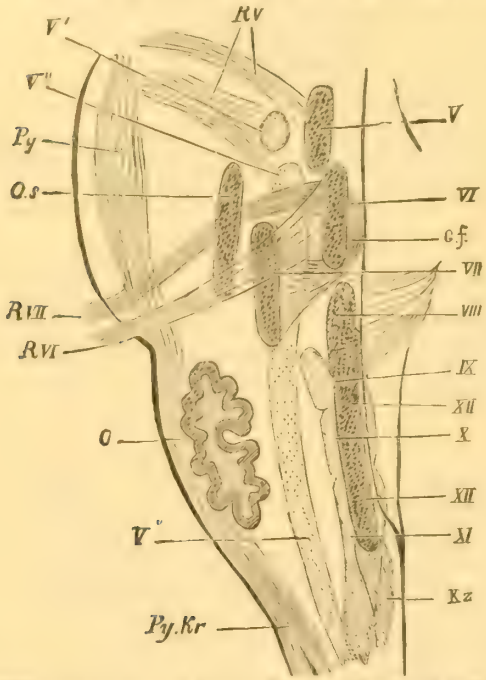

FIG. 3039.—Diagram showing Relative Extent and Position of the Cranial Nerve Nuclei in the Pons and Medulla. Sagittal Section (Erb). *V* to *XII*, nuclei; *RV*, *RVII*, roots of *V*, *VII*; *V'*, sensory nucleus near raphé; *V''*, motor nucleus; *V'''*, ascending root of *V*; *cf*, knee of facial root curving around *VI*; nucleus; *Os*, superior olive; *O*, olive; *Py*, pyramidal tract; *Py*, *Kr*, decussation; *Kz*, nucleus gracilis.

VI nucleus. Under these circumstances there will be conjugate deviation of both eyes toward the side of the abducens paralysis.[1] The act of conjugate movement may also be interfered with without paralysis of the abducens nerve. That act is governed by the VI nerve nucleus, or by a special nucleus in its immediate vicinity as yet undetermined. It involves an innervation of one external rectus muscle and of the opposite internal rectus muscle. But the internal rectus muscle derives its innervation from the third nerve. A crossed connection must therefore be maintained between the abducens of one side and the oculo-motorius of the other side. This connection is maintained by means of the posterior longitudinal fasciculus (Figs. 3026 to 3032, *ld*). A lesion in the pons in the course of this bundle will interfere with the act of conjugate movement without paralyzing either abducens or oculo-motor nerve alone. In none of the cases mentioned is voluntary convergence of the eyes to a point suspended. These conditions may be understood by reference to Fig. 3040.

A very extreme contraction of the pupils is mentioned as a symptom in cases of sudden lesion of the pons. It has not been explained.

Paralysis of the facial muscles is very common, but is usually due to lesions in the nerve outside of the pons. The symptoms which are produced when the facial nerve-root or its nucleus are invaded in the pons, resemble those of Bell's palsy; for all the facial muscles are affected, and an atrophy with reaction of degeneration ensues. The situation of the lesion in the pons can only be determined when other symptoms of pons disease, such as alternating paralysis (Fig. 3029) are present.

Paralysis of the motor portion of the glosso-pharyngeal nerve, with dysphagia or difficulty of swallowing, is a not infrequent symptom of pons disease. It occurs after sudden lesions, such as hæmorrhage or embolism, also as the result of tumors, and most frequently of all in progressive bulbar paralysis.

Paralysis of the motor and vaso-motor mechanisms, governed by the vagus nerve, is a constant symptom of disease in the lower part of the pons and in the medulla.

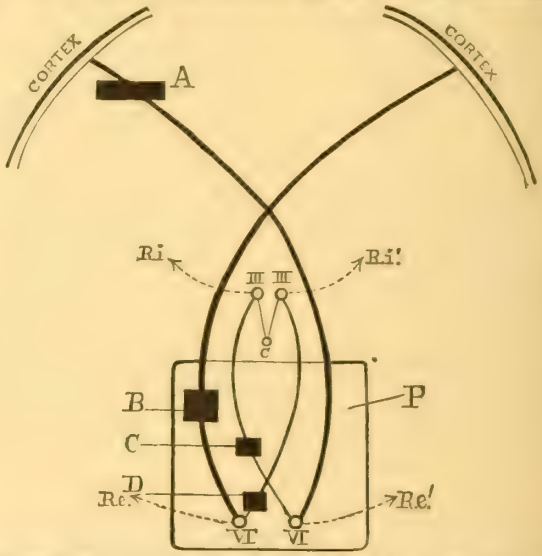

FIG. 3040.—The Innervation of the Muscles of the Eye. (After Hunnius, Zur Symptomatologie der Brückenerkrankungen.) P, pons varolii; III, oculo-motor nuclei, with Ri nerve to left internal rectus, and Ri' to right internal rectus; VI, abducens nuclei, with Re nerve to left external rectus, and Re' to right external rectus; tract from cortex to VI conveys voluntary impulses of conjugate deviation of the eyes; tract from VI to III unites the action of one external rectus with the opposite internal rectus; C, centre for convergence of the eyes which is independent of VI and is actually in connection with the cortex by independent tracts not shown; A, situation of a lesion in the cerebrum producing loss of voluntary conjugate deviation of the eyes to the right; B, situation of a lesion in the pons producing loss of voluntary conjugate deviation of the eyes to the left; C, situation of lesion in the pons in the posterior longitudinal bundle, causing paralysis of conjugate motion to the right; D, situation of a lesion in the pons in the posterior longitudinal bundle, and involving the VI nucleus, causing loss of conjugate motion to the left, with permanent deviation of the eyes to the right.

Arrest of respiration and heart-action, from lesion of this nucleus, is the cause of sudden death, which so frequently attends sudden lesions in the medulla and pons. When the lesion is, however, of a slowly progressive nature (tumor, sclerosis about a hæmorrhage), symptoms of irritation may occur from gradual invasion of the pneumogastric centres. Projectile vomiting; slow, or very rapid, or intermittent, irregular pulse; dyspnœa; loss of voice; polyuria and glycosuria, are symptoms which have been ascribed to such lesions. The two last named symptoms have been associated with tumors in the lower part of the medulla,[2] and upper part of the spinal cord, which have involved the fibres from the vaso-motor centre on their way downward to their exit from the cord at the eighth cervical segment. The intra-medullary nucleus of the spinal accessory nerve is so closely adjacent to that of the vagus, that they are usually involved to-

gether, when difficulty of respiration and articulation ensues. When the spinal portion of the nerve is affected, spasms of the neck occur; but this symptom is characteristic of meningeal affections, and has not been observed in central lesions.

An affection of the hypoglossal nerves or their nuclei is very frequently observed in medullary disease, partly because the nerves pass through the middle of the medulla, and partly because their nuclei are large. If the lesion produces irritation of one nucleus, fibrillary twitchings and spasm in one-half of the tongue may be caused. It is more usual to find paralysis than spasm, in which case the tongue, when protruded, will deviate toward the paralyzed side, and will, therefore, point toward the lesion. But when the tongue is affected by disease in the medulla, it is not unusual for both halves to be involved, and then it is found that the power of protruding it is suspended, and motions in the mouth are also difficult. Hence talking, chewing, and swallowing are interfered with. An electric examination in these cases will demonstrate the reaction of degeneration in the intrinsic muscles of the tongue, and prove that the lesion is medullary, and not cerebral. Anarthria or dysarthria, *i.e.*, imperfect articulation, is, according to Nothnagel, a frequent and important symptom of medullary disease.

2. *The Sensory Nerves* of the pons and medulla are the trigeminal, the auditory, and the glosso-pharyngeal. Lesions which affect the trigeminal nerve and produce anæsthesia of the face, have already been considered. Trophic disturbance of the eyeball has not yet been observed in cases of lesion of the trigeminal root or nucleus. The auditory nerve is occasionally affected in diseases of the pons and medulla. Two sets of symptoms are then produced: one referable to the implication of the fibres conveying auditory impressions, the other due to the irritation or destruction of fibres concerned in the sense of equilibrium. Deafness has been observed in pons disease on the side of the lesion,* and is probably due to destruction of the auditory fibres passing inward to the inner auditory nucleus on the floor of the fourth ventricle, or to an implication of that nucleus (see Fig. 3033). The central course of the auditory tract is believed to be as follows: From the inner and outer auditory nuclei fibres cross the median line in the corpus trapezoides (Fig. 3032, *ct*) to the opposite superior olive, thence turn upward with the lemniscus, pass beneath the corp. quad. post. in the lower lemniscus (Fig. 3026, *l*[1]), thus reach the internal geniculate body, from which a tract passes outward through the lower posterior part of the internal capsule and corona radiata to the temporal lobe of the brain (Figs. 3025, 3033). The course of this tract has been traced by anatomists, and has not yet been confirmed by pathological observation. Lesions at any part of it should produce deafness in one ear. Disturbance of equilibrium may occur from lesions in the lateral portion of the pons, if such lesions interrupt the part of the auditory nerve conveying such sensations to the cerebellum. This part of the auditory nerve passes either directly into the cerebellum through the inferior peduncle, or terminates in the external auditory nucleus, which is connected by fibres with the cerebellum (Figs. 3031, 3032 *e*, *ci*[1]). Vertigo, which is a frequent symptom of pons lesion, and rotatory movements of the body toward one side, which is an occasional symptom of pons disease when the lesion involves the lateral portion of the pons, and the inferior and middle cerebellar peduncles, are probably due to an involvement of this portion of the auditory nerve in the lesion. The rotatory movement is probably due to a voluntary attempt to correct a subjective sense of motion. The patient really suffers from vertigo, and thinks that he is turning or falling toward one side; he therefore tries to prevent this falling by turning toward the other side. The symptom may be so serious that such rotatory movements are constantly kept up until the patient dies of exhaustion. The patient turns toward the side opposite to the lesion (?).

The sensory portion of the glosso-pharyngeal nerve receives the sensations of taste,[3] and in two cases in which its nucleus has been involved a loss of taste has occurred. This symptom is so rarely elicited that it is not known whether lesions elsewhere in the pons or medulla will produce it.

The Vaso-motor Centre.—Lesions in the upper half of the medulla produce marked vaso-motor symptoms.[4] They consist of a general vaso-motor paralysis with flushing of the surface and sensation of heat, and of abnormal sweating. The vaso-motor centre is bilateral, and each centre controls the circulation on the same side of the body. Lesions in its area are so likely to cause sudden death that but few cases can be found in which it was affected (eight cases in my collection). But the symptoms of a vaso-motor character are to be looked for in any case of medullary lesion, and when such symptoms are limited to one lateral half of the body, and are associated with other symptoms of bulbar disease, they are valuable as signs of the situation of the lesion.

There are a few general symptoms, which have been not infrequently observed in pons disease, which require mention. General convulsions is the most constant of these. The majority of sudden lesions (hæmorrhage, embolism) in the pons are ushered in by general convulsions, followed by coma. Nothnagel established the fact that in animals irritation of the pons produces general convulsions, and hence authors have spoken of a convulsive centre in the pons. It is hardly warrantable to hypothecate such a centre. But it is probable that lesions in the pons are capable of producing general convulsions by irritating the motor tracts which pass through it. This is borne out by the fact that when the lesion is a tumor or a sclerosis, *i.e.*, a gradually increasing lesion, convulsions do not occur. Headache, disturbance of vision, vertigo, and psychical changes have been frequently observed in connection with diseases of the pons and medulla, but they are to be ascribed to changes in the circulation or internal cranial pressure, and not to any special local lesion.

It is evident from this review that the symptoms of lesions of the pons and medulla are very numerous, very complex, and very various, in accordance with their extent and the manner of their occurrence. The symptoms in bulbar paralysis are very different from those of softening from embolism. And as almost every case so far recorded has differed from every other in important particulars, it is necessary to study carefully and fully all the symptoms occurring in any case of central lesion. If the cranial nerves are involved, or if there is present alternating paralysis or anæsthesia, the possibility of pons or medullary disease must be considered, and an investigation of the various symptoms here detailed should not be neglected. *M. Allen Starr.*

[1] See Report of Clinical Society, Lancet, March 18, 1887.
[2] Archiv für Psychiatrie, xiii., s. 658, u. S. 671.
[3] C. L. Dana: Jour. Nerv. and Ment. Dis., xiii., 65, 1886.
[4] M. A. Starr: The Sensory Tract in the Central Nervous System, Jour. Nerv. and Ment. Diseases, xi., July, 1884; also, Vaso-motor Neuroses, Pepper's System of Medicine, vol. v.

* It is recorded in five cases in twenty-six. In other cases it may have been present, but was not recorded. Starr: The Sensory Tract in the Central Nervous System, Jour. of Ment. and Nervous Disease, July, 1884.

POPLAR BUDS (*Peuplier*, Codex Med.). The buds of the European Black Poplar. *Populus nigra* Linn., order, *Salicaceæ*, a good-sized tree, closely related to the Lombardy Poplar frequently seen in the older parts of this country as an introduced tree. The black poplar is also sparingly present in New York and elsewhere as a naturalized plant. Poplar buds are one or two centimetres long, less than half as thick, slender, pointed, brown, and shining, externally covered with a resinous varnish, and have an agreeable balsamic odor. They contain *essential oil*, *resin*, *salicin*, a nearly related sweet substance, *populin*, and coloring matters, called *chrysin* and *tectochrysin*.

The therapeutic value of Poplar is probably small. It has some popular reputation, given internally, in rheumatism and phthisis, but is mostly used as an in-

gredient of a pleasant, soothing ointment of mildly stimulating properties.

Allied Plants.—A number of other poplars have similar resinous buds, which are frequently used as substitutes for the above—our so-called "Balm of Gilead," *Populus balsamifera*, var., being one; for the order, see Salix.

Allied Drugs.—See Benzoin, Balsam of Tolu, etc. *W. P. Bolles.*

POPPY, RED (*Rhoeadas Petala*, Br. Ph.; *Coquelicot*, Codex Med.). The petals of this showy European poppy are employed to a slight extent in the form of a red syrup, of little or no medicinal value, but of fine appearance, and occasionally prescribed as a vehicle. It has been sufficiently noticed under *Allied Plants* in the article Opium. *W. P. Bolles.*

PORTAL SYSTEM, RELATIONS OF, TO PATHOLOGY AND THERAPEUTICS. We do not believe that in works on the Practice of Medicine, or, so far as our observations extend, in the instructions given to students at the dissecting-tables or in lecture-rooms, the important relations of the portal system, its bearings upon pathology, therapeutics, and the materia medica, are sufficiently emphasized. The marvellous absorption by the venous radicles of multifarious articles of food and of medicines, whether fluid or solid, mild or powerful, the far-reaching effects of portal obstruction, the rich quality of the blood after it has left the liver, these have not had sufficient stress laid upon them.

Few are told, furthermore, that the "pulmonary *artery*" is in part, if we consider its contents, a misnomer. It is an artery, because it goes *from* the heart and has valves only at its origin. It is a vein, inasmuch as it carries all the *venous* blood collected from every portion of the system; but this blood, again, is not strictly venous, and though not yet vitalized by the oxygen of the lungs, it has been enriched by all the *food* which entered the liver after it had been subjected to gastric digestion, plus the changes wrought upon this blood in the liver itself. Its contents are, therefore, used-up venous blood mixed with highly nutritive elements which are essential to sustain and invigorate the whole organism.

The term "pulmonary *vein*" is still more markedly a misnomer. It is no vein at all, except only that it goes *to* the heart; it carries the richest and most highly vitalized *arterial* blood in the body of man, upon the very eve of its distribution, and prepared to satisfy every need of his system; it possesses the elements for the production of heat and force, it can mend or make bone, muscle, nerve, and supply the pabulum for the exercise of volition, thought, and intellect. Most of these qualities and this power it derives from contributions made by organs comparatively far removed, namely the "portal veins."

These are facts patent, it is true, to every intelligent physician, only not sufficiently considered or enforced.

Let us, then, briefly review the subject in some of its practical bearings; and when the portal vessels are pointed out or referred to, let the student not simply be able to cite their origin and names, but let him realize fully their true position and importance in the economy, whether healthy or morbid.

The liver, the largest gland or blood-making and blood-purifying organ in the body, lies in the very path midway between the stomach and intestines and the heart and lungs. All the veins coming from the stomach and intestines, with scarcely an exception, unite in one trunk and go into the liver; and this was therefore called by the ancients (who understood its importance) the portal vein (vena portæ), the great gateway or portal of entrance into the system. It might well have been distinguished as the "grand trunk." The reason for the high importance of this central canal is that it carries a rich stream of nutritive matter into the heart of the system. But there are, besides, physiological considerations connected with it, and some diseases with the production of which this canal is so intimately concerned that we must invite attention to an explanation of their relations.

The intestines of an adult of ordinary size, though packed away in a very small space, are over thirty-six feet long, or six to eight times the length of the body, and possess about fourteen thousand square inches of surface. They consist of an enormous glandular apparatus—secreting and excreting, but possessing no special absorbent vessels.* Over the entire stomach and intestines, throughout their whole length, there circulate countless myriads of veins (the gastric, superior and inferior mesenteric, and hæmorrhoidal), subdividing, ramifying, and encircling their walls—but these veins never penetrate through their coats, nor with open mouths dip into their interior. Through the walls of these veins, though at their origin infinitely small, is carried by imbibition—as water or other fluid will pass through the insensible pores of a membrane—all the food which has been swallowed, and which the solvent juices of the mouth, stomach, and upper intestines (those of the stomach being strongly acid) have *digested* and prepared for the nourishment of the body. We say that all, every portion of this highly nutritious material (save oils and fatty matters), upon which our life depends, having penetrated, by endosmotic action, into the interior of these numerous and widely disseminated congeries of veins, which converge into one channel (the portal canal), is carried directly to the liver. We can compare these veins, thus filled with nutritive material, to the countless rills which flow from mountain, plain, and valley, draining a wide extent of country, and gathering the elements of fertility from every quarter, till they unite in one full stream, to pour into the ocean their rich and various stores.

When these products of stomach and intestinal digestion reach the liver, they undergo certain other digestive changes which we need not describe in detail, saying only that the starchy matters contained in the food, acted on by the diastase of the saliva and pancreatic juice and changed to dextrine and sugar, are further converted in the liver into glycogen, a body allied to the dextrines, and again reconverted into sugar—which latter is serviceable in heating the body. The materials derived from flesh, meats, etc., which have been already digested in the stomach and intestines, go to make up the elements of the *blood;* they furnish what Sir William Gull, of St. Bartholomew's Hospital, aptly calls the "raw material of the blood." They then pass out of the liver to the vena cava ascendens, to reach the heart, from whence they are sent to the lungs (that they may be exposed, by a similar endosmotic action, to the action of the air), to be again returned to the heart. But before the blood has left the liver, bile has been extracted from it, a portion of which is retained in its proper reservoir, the gall-bladder, while a portion finds its way back into the intestines, to assist, after its own special manner, in the intestinal digestion; in conjunction with the pancreatic fluid, it breaks up and emulsionizes fatty materials of the food—which ultimately pass into the thoracic duct, and reach the heart by a different channel.

So that even the most uninstructed need not be told now that those veins which go to the liver, as described above, are not, strictly speaking, *veins*, like the rest of the veins in the body, carrying dark, used-up blood to the heart, as, with a single exception all the veins do. These portal veins contain some of the very richest material in the body, gathered, as we have shown, from the food which man has swallowed to gratify his natural and proper wants or his greediness. If he habitually takes too much food, the liver is overtaxed as well as the

* In M. Foster's Text-book of Physiology, third English edition, 1880, he says of the entrance of the chyle into the lacteals: "The lacteal begins as a club-shaped (or bifurcated) lymphatic space lying in the centre of the villus, and connected with the smaller lymphatic spaces of the adenoid tissue around it; it opens below into the submucous lymphatic plexus from which the lacteal vessels spring. . . . That the finely divided fat does pass from the intestine through the epithelial envelope of the villus, into the adenoid tissue, and so into the lacteal chamber, is certain, but much discussion has arisen as to the exact mechanism of the transit." So whether there is true absorption or osmosis is uncertain.

stomach, and he becomes overfat, or suffers from enlargement of the organ, from dyspepsia, indigestion, headaches, etc.

It must be remembered that all this rich contribution made by the stomach and intestines to the veins which penetrate the liver is not only *food* of every variety and description (with the exceptions made), digested flesh or fish, bread, vegetable substances, fruits, sweet sugary matters, grains, etc., but besides these, all the *fluids* we drink take the same course, and enter the liver with the other digested substances. These drinks may be, and are, water, spirits, wines, syrups, and, be it observed, anything capable of solution by the juices of the stomach, or dissolved in the spirits, wine, or water, namely, poisons or medicines—whether fluid or solid, mineral or vegetable, powders or liquids—all, save oily and fatty substances, pass straightway to the liver. A glass of wine or a cup of tea which has been swallowed, and which affects the head in half a minute, or the kidney in a very brief space of time, has passed through this portal vein, and has entered the liver to reach the heart. Anything that the wine may contain, medicines or poisons, ingredients of any kind—beneficial or hurtful—all take the same route through the liver.

We can now readily understand the vast importance of this great gland, or viscus, in the economy of the system, and what it has to do, whether healthy or diseased, with our food, our drink, our nourishment, or our *cure;* for we depend upon it for health and strength, as well as for transmitting, and to a certain extent modifying, almost all the remedial agents which the physician in his best judgment deems necessary for the cure or relief of the sick.

In this preliminary narration of facts, which we hold to be essential to any proper understanding of the subject, we have also to state, that both the stomach and intestines, and the liver reciprocally react, in turn, upon each other; and when the rules of life or the teachings of common sense are violated, or when disease invades one of these organs, the other is liable to suffer through means of this very circulatory arrangement—this inter-dependence which we have been describing. Thus, a catarrh of the stomach and intestines, causing the pouring out of a large amount of mucus, or a dysentery (a flux accompanied with pus and disorganized blood) may impair or poison the blood which goes to the liver. Or, on the other hand, if the liver is diseased, enlarged, or congested, it fails to give passage, as in health, to the blood, and to the rich material which is taken to it by the veins—its channels of entrance or exit are blocked up; the blood flows back, and the venous contents regurgitate, we may say, upon the already diseased or the healthy stomach or intestines, causing congestion of them, deranging their proper functions, and giving rise to repletions, to indigestions, to looseness of the bowels, to dysentery, or other disturbance.

We may add that the spleen also suffers if the liver is blocked up, for the only other veins which go to the liver with the gastric and intestinal veins are those which come from the spleen. So this organ is similarly liable to be affected by obstructive diseases of the liver.

Besides colds (catarrhs), dysenteries, and congestions of the stomach and intestines, which are caused or increased by diseased conditions of the liver, we must call attention to the extreme lower portion of the bowels—the rectum and fundament. These parts of the bowel are very richly supplied with (valveless) veins, of which the superior hæmorrhoidal enters the portal canal and goes to the liver. They bleed, consequently, when, in trying to make their way through this organ, their path is obstructed; the blood in them flows back, engorges, swells up the vessels of the lower intestines, and we have bleeding piles. We can readily understand, then, why, though the lower bowels and rectum are far removed from the liver, they sympathize with that organ; and how such medicines as calomel, sanguinaria, podophyllum resin, taraxacum, soda, Epsom salts, etc. (which act upon the liver and intestines by stimulating their secretions and then emptying them), relieve dysenteries, colds of the stomach (catarrhs), hæmorrhoids, or other intestinal diseases caused by congestion or engorgement, or arising from whatever influences.

Medicines, or local means also, which act specially in emptying the lower bowels, aloes, Epsom salts, etc., the application of leeches, enemata, etc., naturally have the power of relieving plethora or engorgements of the liver. If the heart, especially the right chambers, or the lungs are diseased or congested, the liver is unable to empty itself properly, so that it sympathizes also with these organs.

Dr. L. F. Warner, of Boston, contends that portal congestion, as a clinical fact, always "intensifies, if not causes, pelvic congestion," and he advises medicines acting on the liver to relieve the uterus. In this he is sustained by Dr. Montrose Pallen. It appears to the writer that the uterine organs discharge their venous blood much more fully through the vena cava ascendens, and thus escape much complication with the liver. In *Gross's Journal*, as far back as 1859, it was stated that sterility in women was often dependent upon fissure, hæmorrhoids, and disease of the rectum, because of their mutual relations with the uterus—both organs being supplied with blood from the internal iliac artery, and with nerves from the sacral plexus. We argue that the uterus is not materially emptied by the hæmorrhoidal or mesenteric veins.

The tendency among many physicians, and especially the laity, to ascribe the origin of many ailments to the liver is, we believe, not ill-founded, when we consider its numerous relations, its liability to be the seat of morbid or malignant growths, to be disturbed by excesses in eating and drinking, by alternations of temperature, by the effects of protracted high temperatures, by the alternate congestions caused by exposure to malaria, and the gastro-enteric and splenic complications through the route of the portal veins, to which reference has been made.

It is our opinion that to the existence of gastro-duodenal irritation (no true *inflammation* being present) are to be ascribed "gastric remittent fevers," which we have claimed to be a distinct disease. Uncomplicated gastric remittent fevers can occur on the highest mountain plateaus where not a whiff of malaria exists. We believe also that when fevers of malarial origin are "remittent," or "continued," and not "intermittent," it is *because* of the gastro-duodenal and hepatic irritation; *i.e.*, a malarial remittent is an intermittent *plus* gastro-enteric or gastro-hepatic irritation which is the ever-present, de facto, *cause* of the continuous abnormal temperature—the *pyrexia*. The malarial element is responsible only for the cold stage and the periodicity. There are *bilious* remittents, called so because the liver is especially implicated in addition to the gastro-duodenal tract. We never hear of a bilious intermittent. In pure intermittents there are no gastro-enteric or gastro-hepatic complications (save only enlargement of the liver and spleen after repeated chills), and hence for the cure of these quinine or arsenic alone suffices; whereas for the relief of the continued or remittent forms other remedies are required to reduce the irritation (or inflammation), such as alteratives, revulsives, antipyretics, cold applications, etc., and this sustains the correctness of the Hippocratic maxim, "*Naturam morborum curationes ostendunt.*"

F. Peyre Porcher.

PORTER SPRINGS. *Location and Post Office*, Denver, Arapahoe County, Col.

Access.—By carriage, from Denver across the Platte River.

Analysis (Professor E. J. Mallett, Jr.).—One pint contains:

	Grains.
Carbonate of soda	0.726
Carbonate of magnesia	0.124
Carbonate of lime	1.285
Chloride of sodium	0.666
Chloride of magnesium	0.142
Sulphate of potassa	0.037
Sulphate of soda	3.142
Sulphide of sodium	0.228
Silicate of soda	0.112
Oxide of iron	0.187
Ammonia	trace
Total	6.959

THERAPEUTIC PROPERTIES.—This is an alkaline water containing sulphates and an appreciable amount of iron. It should act as an efficient tonic

There are hotels and baths at the springs.

G. B. F.

PORTLAND, ME. The accompanying chart, representing the climate of the city of Portland, Me., and obtained from the Chief Signal Office, in Washington, is here introduced for convenience of reference. A detailed explanation of this chart, and of the other similar charts published in the HANDBOOK, is given in the article entitled Climate, where also the reader will find suggestions as to the best method of using these charts.

Climate of Portland, Me.—Latitude 43° 39′, *Longitude* 70° 15′.—*Period of Observations, January* 1, 1872, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 25 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January	19.9	27.3	22.6	23.2	32.3	16.5	31.9	16.1	58.0	35.0	8.0	−11.5	20	29
February	21.9	30.6	25.5	26.0	31.8	19.2	36.2	20.0	58.0	15.0	12.0	−7.0	20	19
March	29.4	37.1	31.4	32.6	38.8	23.2	44.2	25.0	65.0	15.0	23.0	−7.0	26	26
April	40.5	48.0	41.0	43.1	48.8	36.4	52.8	37.3	78.0	58.0	37.0	14.0	21	18
May	52.8	59.8	52.0	54.8	59.7	51.5	64.1	47.9	94.0	72.0	41.0	34.0	22	23
June	61.9	69.7	60.5	64.0	66.4	60.8	73.7	56.3	94.0	81.0	51.0	42.0	22	18
July	67.6	75.2	66.3	69.7	72.3	68.0	79.0	62.4	97.0	84.5	57.0	51.0	19	20
August	65.2	73.8	65.1	68.0	70.5	65.0	77.1	61.1	95.0	83.0	58.0	48.0	20	19
September	57.7	65.7	58.5	60.6	64.2	58.2	69.5	55.1	94.5	78.5	50.5	37.0	25	20
October	47.5	55.0	48.9	50.4	55.5	46.8	58.8	44.6	83.0	64.0	38.0	28.0	22	19
November	35.8	41.3	37.0	38.0	43.2	28.9	46.7	33.6	66.0	48.0	26.0	−6.0	20	19
December	25.2	31.0	27.0	27.7	41.2	17.7	36.9	23.3	57.0	42.0	14.0	−17.0	21	26
Spring	.....	.....	.....	43.5	48.0	39.2	.....	.....	.....	.....	.....	.....	.....	.....
Summer	.....	.....	.....	67.2	69.4	65.0	.....	.....	.....	.....	.....	.....	.....	.....
Autumn	.....	.....	.....	49.6	52.2	45.7	.....	.....	.....	.....	.....	.....	.....	.....
Winter	.....	.....	.....	25.6	30.7	19.5	.....	.....	.....	.....	.....	.....	.....	.....
Year	.....	.....	.....	46.5	49.1	43.6	.....	.....	.....	.....	.....	.....	.....	.....

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	Miles.
January	69.5	72.6	12.0	9.7	21.7	3.22	N.W.	7.6
February	65.0	69.5	11.2	9.8	21.0	2.91	N.W.	8.4
March	72.0	68.4	11.6	7.2	18.8	3.25	N.W.	9.1
April	64.9	62.8	11.4	7.7	19.1	2.76	N.W.	8.8
May	60.0	64.7	11.8	8.3	20.1	2.94	S.	7.8
June	52.0	68.7	13.8	7.8	21.6	3.76	S.	6.9
July	46.0	70.1	14.2	8.6	22.8	3.52	S.W.	6.6
August	47.0	71.6	12.2	11.1	23.6	3.12	S.	5.7
September	57.5	73.6	11.1	10.2	21.3	3.16	S.	6.7
October	55.0	70.8	11.5	8.9	20.4	3.66	S.W.	7.3
November	72.0	70.8	10.6	9.1	19.7	3.85	N.W.	8.3
December	74.0	73.2	12.7	9.0	21.7	2.89	W.	7.9
Spring	101.0	65.3	34.8	23.2	58.0	8.95	N.W.	8.5
Summer	55.0	70.1	40.2	27.8	68.0	10.40	S.	6.4
Autumn	109.5	71.7	33.2	28.2	61.1	10.67	S.W.	7.4
Winter	75.0	71.8	35.9	28.5	64.4	9.02	N.W.	8.0
Year	111.0	69.7	144.1	107.7	251.8	39.04	N.W.	7.6

The range of temperature is decidedly less at the former than it is at the latter station. (See Columns C, D, E, F, and J.) The rainfall is much greater, the relative humidity is higher (especially in winter), and the number of cloudy days is much greater (especially in winter) at Portland on the Pacific than at Portland on the Atlantic. The great cloudiness of the Oregon winter weather is a feature of the climate not characteristic of any other part of the United States except the Lake Region and St. Lawrence Valley District. (See charts of Rochester and of Burlington.)

In short, the reader who is at all familiar with the geography of climate, will observe a close resemblance between the climatic conditions characteristic of Portland, Ore., and those prevailing along the western coast of the European continent. The temperatures of the Oregon coast are strongly suggestive of those found throughout Northwestern Europe. The annual distribution of the rainfall is also in marked contrast to that prevailing on our Atlantic coast and throughout the greater part of our territory; and the almost rainless summer, with heavy winter rainfall, is a feature of climate in which the Oregon coast resembles the Mediterranean basin rather than the more northerly parts of Europe. An exact parallel between the Pacific coast climates of this continent and the Atlantic coast climates of the European continent, cannot be drawn; a general resemblance between the two, however, exists, and a great unlikeness in both to those climates which are found on our Atlantic seaboard, or, in fact, anywhere throughout the United States east of the Rocky Mountains.

H. R.

PORTLAND, ORE. The chart on opposite page, representing the climate of the city of Portland, Ore., and obtained from the Chief Signal Office, in Washington, is here introduced for convenience of reference. A detailed explanation of this chart, and of the other similar charts published in the HANDBOOK, is given in the article entitled Climate, where also the reader will find suggestions as to the best method of using these charts.

H. R.

Climate of Portland, Oregon.—Latitude 45° 32′, *Longitude* 122° 43′.—*Period of Observations, November* 1, 1871, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 27 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from Column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	36.9	42.5	39.5	39.6	44.6	30.5	45.2	34.4	58.0	52.0	27.0	3.0	17	23
February...	38.6	45.6	41.8	42.0	46.4	33.0	46.5	34.1	63.0	52.0	33.0	7.0	20	26
March.....	42.4	51.8	47.8	47.3	51.9	41.2	55.8	39.6	76.5	55.0	34.0	25.5	29	24
April.....	44.3	57.5	52.3	51.3	55.3	47.3	60.8	43.1	85.0	67.0	40.0	28.0	24	19
May.....	48.5	62.4	57.3	56.0	59.7	53.0	67.4	46.9	86.0	75.0	43.0	33.0	21	18
June.....	53.5	68.2	63.4	61.7	65.1	59.5	72.9	52.6	99.0	81.7	59.0	42.0	23	23
July.....	56.6	73.0	69.0	66.2	71.2	63.7	76.8	54.9	95.5	85.0	51.0	46.0	21	22
August.....	55.9	71.7	66.9	64.8	67.1	62.6	75.4	54.3	91.0	80.0	50.0	43.0	19	23
September..	52.9	68.1	61.9	60.9	64.5	59.1	70.7	50.7	90.0	79.5	44.6	39.0	17	20
October.....	47.8	58.6	52.6	53.6	58.6	49.8	59.2	45.0	79.0	63.8	42.0	31.0	19	22
November..	42.0	48.6	44.7	45.1	49.2	42.3	51.4	39.1	68.0	58.0	34.0	22.5	21	23
December..	39.1	44.1	41.6	41.6	47.8	38.1	48.8	36.6	63.0	52.0	33.0	3.0	21	21
Spring.....	.....	.....	.....	51.5	53.1	47.9	....	....	.....	.....	.....	.....	.....	.....
Summer....	.....	.....	.....	64.2	66.3	62.1	....	....	.....	.....	.....	.....	.....	.....
Autumn....	.....	.....	.....	53.0	55.5	51.2	....	....	.....	.....	.....	.....	.....	.....
Winter.....	.....	.....	.....	41.0	43.3	37.8	....	....	.....	.....	.....	.....	.....	.....
Year.....	.....	.....	.....	52.4	53.9	50.4	....	....	.....	.....	.....	.....	.....	.....

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
						Inches.	From	Miles.
January....	55.0	78.4	7.0	3.4	10.4	7.34	S.	6.0
February...	56.0	78.3	6.3	2.3	8.6	8.11	S.	5.1
March.....	51.0	75.9	7.0	4.4	11.4	7.27	S.	5.1
April.....	57.0	70.1	9.2	5.2	14.4	3.48	S.	4.7
May.....	53.0	64.9	9.9	5.1	15.0	2.44	N.W.	4.8
June.....	57.0	64.3	9.8	7.2	17.0	1.82	N.W.	4.7
July.....	49.5	63.7	7.4	15.3	22.7	0.71	N.W.	4.7
August.....	48.0	67.4	9.2	14.5	23.7	0.81	N.W.	4.1
September..	51.0	69.2	9.5	12.4	21.9	1.62	N.W.	4.2
October.....	48.0	77.6	9.9	7.1	17.0	4.95	S.	4.1
November..	45.5	78.4	8.8	4.7	13.5	7.37	S.	4.5
December..	60.0	79.5	7.8	3.9	11.7	8.27	S.	4.7
Spring.....	60.5	70.3	26.1	14.7	40.8	13.19	S.	4.9
Summer....	57.0	65.1	26.4	37.0	63.4	3.34	N.W.	4.5
Autumn....	67.5	75.1	28.2	24.2	52.4	13.94	S.	4.3
Winter.....	60.0	78.7	21.1	9.6	30.7	23.72	S.	5.3
Year	96.0	72.3	101.8	85.5	187.3	54.19	S.	4.7

POST-MORTEM EXAMINATIONS. Synonyms.—Autopsy, necropsy; Latin, *Autopsia cadaverica, sectio, obductio;* Fr., *nécropsie, autopsie cadavérique;* Ger., *Leichenschau, Section, Obductio.* An examination of the body after death, to investigate the condition of the various parts of the body, to note any changes in the organs, and to determine as far as possible the cause of any such changes.

General Considerations.—An article intended, as this is, to aid the general practitioner in making a post-mortem examination would fall short of the mark were it to give simply the various cuts to be made in order to expose and permit of the examination of the different organs. While it would be out of the question, in a handbook, to detail all the possible alterations in the viscera, and the method of their recognition, yet there are several points, apart from the question of the cuts to be made, which deserve attention.

The sooner after death an autopsy is made the better, as putrefactive changes modify the appearances of pathological as well as of normal organs.

In case an autopsy is to be held, the undertaker should be requested to postpone the injection of any embalming-fluid until the examination has been made, as the preservative fluids modify considerably the appearances, owing to the coagulation of albumen and the alteration of color produced thereby. If for any reason the autopsy is to be made late, it is desirable, where this is possible, to have the body kept on ice.

What shall the physician take to the house, and what may he rely on finding there? He should take instruments, twine, a sponge, and a rubber sheet a yard square. The fewer instruments he can get along with the better; there is less to carry; fewer to soil, and less liability of leaving any behind.

One needs a stout knife from seven to nine inches in length, of which half belongs to the handle, half to the blade. The blade should be from three-quarters of an inch to an inch and a quarter in width, varying according to the length (Fig. 3041).

Fig. 3041.

Also a sharp-pointed scalpel and a medium-sized pair of scissors. A pair of small, probe-pointed scissors, as represented in Fig. 3042, is very useful, though not absolutely necessary.

One needs also a pair of forceps (Fig. 3043) and a large needle (a sail-needle that can be bought at a hardware-store for a few cents will answer the purpose).

Fig. 3042.

Two other instruments, not absolutely essential, though very convenient, are the costotome (Fig. 3044), a stout pair of shears for cutting the ribs when calcified, and the enterotome (Fig. 3045), a pair of long-handled scissors having one blade terminating in a rounded, hooked end, used in opening the intestines.

This outfit will serve for any autopsy in which the brain and cord are not to be removed.

To open the head, a saw (Fig. 3046), a chisel (Fig. 3047), and a hammer having the handle terminate in a hook (Fig. 3048) are necessary.

For removing the spinal cord, a chisel known as a rachitome (Fig. 3049) is very useful, though the ordinary straight chisel will answer the purpose.

One of the first requisites in an autopsy made in a private house is cleanliness, and in no way is this so much aided as by having a good sponge; a medium sized, soft, lamb's-wool sponge is the best. The physician should never rely on finding this article at the house, but should take one with him. After the autopsy it can be washed with soap and water, and is then ready for use at the next autopsy. The better the quality of the sponge the longer it will last and the better work it will do.

Fig. 3043.

At the house there can be obtained the following articles: Half a dozen newspapers, several pieces of old cotton cloth, a slop-pail, and, if there be no running water, a pitcher of water.

The physician cannot be too careful to avoid wounding the feelings of the family in the house where the autopsy is made. A room left in a state of confusion, or the soiling of carpet, chairs, or utensils with drops of blood, not only gives offence to the friends, but often prevents the careless physician getting permission for autopsies in the future, as the family are very likely to give their neighbors an account of Dr. A.'s slovenliness.

In making an autopsy in a private house, it is often necessary to alter the position of table, chairs, or the like. Before any change is made, it should be the duty of the physician to take mental note of the arrangement of articles in the room, in order that, when the autopsy is finished, everything may be restored to its former place.

All articles required in making the examination should be obtained before the autopsy is begun.

The body will be found either upon a bed, with or without a board under it, or upon an undertakers' frame set on horses, or in an ice box. In any of these positions the examination can be made without moving the body, unless the head is to be opened, which cannot be done with the body in an ice-box except the head be raised and supported above the level of the box.

The clothing covering the trunk should be torn down the middle line, in front, and drawn to either side. Newspapers should then be tucked in at the sides of the body, beneath the head and over the pubes, so as to cover the clothing, but to leave exposed the whole anterior surface of the trunk from the chin to the pubes. Should any fluid be spilled later, it will fall upon the paper and not soil the clothing.

Fig. 3044.

The rubber sheet should be spread out on the floor near where the operator stands; the slop-pail is to be placed upon it; the sponge should be moistened and be laid near the hand, ready for instant use; the instruments are to be placed upon a newspaper spread out upon the thighs of the corpse. All appliances are to be made ready before any cutting is done. Once a beginning is made, the performer's hands become so bloody that nothing can be touched later without soiling.

The physician should examine his hands carefully with reference to the presence of cuts or abrasions of any sort. If there be any, they should be covered with contractile collodion. Do not use flexible collodion: it is likely to peel off during the autopsy. While performing the autopsy the operator should be careful to avoid scratching, cutting, or pricking his hands. If there is a suspicion in his mind of a wound received, it is best to wash and examine the place at once. The man who performs an autopsy may well apply to himself Spenser's line, "Of hurt unwist most daunger doth redound." Any wound should be thoroughly washed, squeezed, disinfected, and covered with collodion. The writer's experience leads him to believe that specialists in pathological anatomy, having their hands, as they do, almost daily in contact with dead bodies, are far less liable to infection from scratches or cuts than are those who only occasionally make an autopsy. Hence the greater importance of care in this respect on the part of the general practitioner.

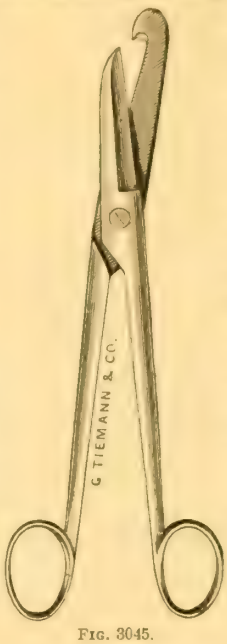

Fig. 3045.

Every autopsy should be thorough, and should be made according to some definite method. The physician ought always to bear in mind the fact that an autopsy once made is made for all time. There is no going back, as there is to the bedside, for further examination in regard to obscure points. Whatever is to be observed must be observed before the physician leaves the house. Further, when organs or parts are separated in the dissection their relations are lost. Hence the importance of noting certain points before organs have been removed or their relation to other parts lost. A proper order in the various steps in an autopsy is of the first consequence.

That method is obviously the best by means of which the most will be discovered and the least overlooked. Nothing but practical experience can determine such a method, and the one given here is that which has been found by repeated trials to give the best results. It is essentially the method taught by Virchow and his pupils.

Method of making a Post-mortem Examination.—An autopsy consists of two parts—the external examination or inspection and the internal examination. In a medico-legal autopsy the inspection is of the first importance. In the ordinary autopsy inspection should consist in noting the size, development, and nutrition of the body. Under the head of nutrition the amount of subcutaneous adipose tissue and the size of the muscles should be observed, the former by pinching up a fold of the skin. The presence or absence of rigor mortis, the degree of lividity of the dependent portions, should be noted. Among the common abnormalities are variations in the color of the skin, œdema of subcutaneous connective tissue, localized or diffuse, and localized lesions of many kinds. A greenish discoloration of the abdomen, if present, should always be noted, as it indicates that putrefactive changes have begun, and this fact may modify the interpretation of appearances observed in the internal organs.

Fig. 3046.

Internal Examination.—In the majority of autopsies performed by the general practitioner the examination is limited to the thorax and abdomen. In case the head is to be opened it should be done before the thorax, otherwise much of the blood in the veins will have escaped through the divided superior cava and a correct determination of the amount of blood originally in the brain cannot be made. The spinal cord is best removed after the brain, but before the thoracic and abdominal cavities are opened, especially in a private house, because of the soiling which is sure to take place from escape of blood from the latter cavities, if they have been first examined, when the body is turned on its face.

The best order of procedure, then, is brain, spinal cord, thoracic and abdominal organs. Inasmuch as the thorax and abdomen only are examined in the majority of cases, the method of doing these will be given first, then the method of examination of brain, and finally of the spinal cord.

Fig. 3047.

The character of the incisions made in an autopsy is the opposite of that of an ordinary dissection. In a dissection one uses the point of a scalpel held like a pen, the fingers and wrist alone being moved. The point of the knife describes the arc of a circle, thus making a series of irregular nicks. Although such cuts are well adapted to the isolation of parts in an anatomical dissection, yet they are the worst possible cuts for removing organs and displaying the interiors, requiring much time and leaving an irregular, hacked surface. The cuts to be made in an autopsy are long, sweeping ones, using the whole cutting-edge of a large knife held firmly in the fist in a line with the forearm; the wrist should be kept immovable, the elbow- and shoulder-joints alone being moved. In this way one may rapidly make large incisions having smooth surfaces and a straight bottom.

One other point is worthy of mention. All parts should be put upon the stretch when they are incised; but put them upon the stretch first, then cut. Never try to seize and cut at the same time, as one is in this way liable to cut one's self.

To examine the thorax and abdomen, take the large knife already described (Fig. 3041), grasp it firmly in the fist, make an incision in the middle line anteriorly, beginning at the sternal notch and ending at the pubes. The knife should be held parallel to the body, so that its whole cutting-edge is brought into use. Over the sternum the incision should be carried to the bone; over the abdomen to a depth varying with the thickness of the abdominal wall, going nearly but not quite through it.

Fig. 3048.

It is best to carry the long primary incision to the left of the umbilicus, so as to avoid the round ligament. Next, by means of several short cuts carry the incision through the abdominal wall at the tip of the sternum, making it long enough to admit two fingers. Insert the fore and middle fingers of the left hand into this incision, and make strong upward and outward traction on the right half of the abdominal flap. This serves the double purpose of drawing away the flap from the intestines, thereby lessening the risk of cutting them, and it puts the abdominal wall upon the stretch, permitting of its easier incision. Now complete the cut through the abdominal wall to the pubes.

Next divide the pyramidales muscles at their attachment to the pubes; this allows of a greater lateral withdrawal of the flaps, and gives better opportunity for the examination and removal of the abdominal organs. In some countries it is customary to make transverse counter-incisions in the abdominal wall from the umbilicus outward. This is a bad practice. It is unnecessary so far as room is concerned, and there is the disadvantage of increased mutilation, more sewing, and greater liability of leakage.

While the long primary incision is being made the operator should have the sponge ready to absorb any fluid that may escape. If there be much fluid in the abdominal cavity, it should be removed at this stage.

The next step in the autopsy is to determine the position of the arch of the diaphragm. To do this, insert the right hand, palm upward, beneath the ribs; pass it along the inner surface of the ribs until the highest point of the diaphragm is reached, remembering to go, on the right side, to the outside of the falciform ligament of the liver. Put the forefinger of the left hand upon the external surface of the thorax corresponding to the position of the fingers inside. Withdraw the right hand and, beginning at the clavicle, count downward ribs and interspaces until the finger of the left hand, previously placed on the outside, is reached. This gives the position of the arch. Its usual position is the fourth rib on the right, and the fourth interspace or fifth rib on the left. It is lowered when the lung is solidified, and when there is fluid or gas in the pleural cavity. The fluid or gas may be so abundant as to bulge the diaphragm downward. (To determine presence of gas in pleural cavity, see later.)

The next step is the removal of skin and muscle from the anterior surface of the thorax, so as to lay bare the sternum, cartilages, and bony ribs for a distance of two to three inches outside the articular line.

Fig. 3049.

The abdominal flap is seized in its upper part by the left hand, and turned forcibly outward; by doing this the rectus abdominis at its point of origin, the lower margin of the ribs, and the attachment of the diaphragm are exposed. The heel of the blade of the large knife is now placed upon the origin of the rectus, and by means of a single sweeping stroke, carried just above the lower border of the ribs, the rectus and the diaphragmatic attachments are severed. Then seize the flap a little higher up, turn it forcibly outward so as to put the muscles on the stretch, and divide the parts which have been made tense. Continue the cuts in like manner until the ribs on the right side are exposed, removing all the muscle with the flap so as to leave the ribs clean. Repeat the process on the left side. Then expose the sterno-clavicular articulation by dividing subcutaneously the tissues that cover it.

Before removing the sternum a general inspection of the abdominal cavity should be made, to note whether there be an increase in the amount of the serous fluid normally present, or abnormal contents. The reason for making the cursory examination at this stage of the autopsy is that if there be fluid in either of the pleural cavities, some of it will be likely to escape into the peritoneal cavity on removal of the sternum; hence it would be impossible to determine later whether fluid found in the abdominal cavity was there originally or had come from the pleural cavity.

If pneumothorax is suspected, the presence of gas in the pleural cavity should be determined at this stage of the autopsy. It is best done by making a double fold of the skin flap over the anterior portion of the thorax on the suspected side. Water is poured into the space between the folds, making a little pool. The sharp-pointed scalpel is now driven through the muscle of an intercostal space, where the water lies, and the effect noticed. If there be gas in the pleural cavity, it will escape by bubbling through the liquid; otherwise the water will disappear through the opening. One must not mistake the collection of gas from putrefactive changes in the pleural cavity for gas which has collected during life. If present from putrefaction, it will be double-sided, and there will be other evidence of putrefactive changes in the tissues.

The sternum is now to be removed. This is done by opening the sterno-clavicular articulation, and dividing the cartilages of the ribs about one-eighth of an inch from their junction with the bony ribs. The knife to be used is the small pointed scalpel already described. The

guide to the position of the sterno-clavicular articulation is the tendon of the sternal attachment of the sterno-cleido-mastoid muscle. Insert the knife above the clavicle about one inch outside this tendon; then by an up-and-down motion divide the soft parts till the tendon is reached; turn the knife so as to enter the joint, then follow the joint in a semicircle, with the same up-and-down motion of the knife, not trying to guide it, so far as its vertical direction is concerned, for the plane of the joint is a constantly varying one, hence the importance of holding the knife loosely in the fingers and letting it take its own course. Do not remove the knife after the joint has been opened, but continue the incision outward along the under border of the clavicle for an inch outside the joint, then turn the knife at right angles to its former position and cut the first rib. In opening the sterno-clavicular joint, care should be taken not to carry the point of the knife below the inner part of the joint, as the innominate veins lie beneath and are liable to be cut.

The costal cartilages are to be cut in the place indicated above by a quick, forcible stroke with the scalpel, the heel of the knife striking upon the next rib below as the blade incises the rib. In this way the blade is prevented from going too deeply, and thereby injuring the lung. All the cartilages having been divided, the sternum is to be depressed below the level of the bony ribs and the intercostal muscles cut, the knife being held parallel to the ribs to avoid cutting the lung. Remove the sternum by lifting its lower end up, cutting the attachments of the diaphragm to it, and also the tissues of the anterior mediastinum, keeping as close as possible to the posterior surface of the sternum so as to avoid opening the pericardium. When the under surface of the sterno-clavicular joint is reached some difficulty will be experienced in removing the sternum, owing to the resistance offered by the firm ligaments of the joint, but by prying the sternum outward these ligaments are put upon the stretch, and can then be readily cut with the point of the knife.

The sternum having been removed, a general view of the anterior mediastinum should be taken, especially with reference to the presence of serous fluid or pus in its meshes.

Although the heart is the first organ of the thorax to be examined, yet the pericardium should not be opened until a cursory view of the pleural cavities has been taken with reference to the presence of fluid; for here, as in the peritoneal cavity, fluid present may have come from the pericardium, if that be first opened.

Open the pericardium by seizing the anterior portion of the parietal layer with the forceps and, lifting it up (if there be adhesion of the pericardial surfaces, as a result of earlier inflammatory processes, it will be made apparent by the inability to raise the anterior portion of pericardium), nick it with the scissors; cut upward as far as the reflection of the pericardium upon the aorta; then cut downward to the right and also toward the apex. The incision will have the form of an inverted Y. Lift up the heart and note the contents of the pericardium and its character (serum, fibrin, pus, blood). Also note the appearance of both pericardial surfaces. Examine the heart with reference to its size, shape, and the contraction of its walls. Then open the four cavities of the heart *in situ*, to determine the character and amount of their contents. The method is as follows: Let the heart rest upon the palm of the left hand, with the thumb upon the upper surface; turn the heart toward the left; this will make prominent the right auricle, and will bring into view the superior and inferior cavæ where they join the auricle. Make an incision into the auricle at right angles to the cavæ. Next turn the heart back to its former position; lift the thumb from the anterior surface and incise the right ventricle by a cut parallel and close to its right border, remembering not to carry the cut to the apex, as this is formed by the left ventricle only. Open the left ventricle by an incision along the left border a little to the right of and parallel to the coronary vessels. To open the left auricle, put the forefinger in the cut in the left ventricle and the thumb into the cut in the right ventricle, then lift up the heart and carry it toward the right of the body; in this way the left auricle, with the two left pulmonary veins entering it, will be seen. Open the auricle by a crescentic cut, beginning in the upper vein, thence into the auricle, and outward into the lower vein. Introduce one or more fingers into the incisions and note the amount of the contents and their character. The left ventricle is contracted and empty, unless the individual has died from paralysis of this part of the heart, when it will be found distended with blood.

The right ventricle and both auricles are usually distended with blood, which may be fluid, as in death from suffocation, or more or less coagulated. In every case of sudden death it is desirable to open the pulmonary artery *in situ*, in order to determine the presence or absence of emboli.

Now remove the heart from the body by lifting it vertically upward, cutting across in succession the inferior cava, superior cava, pulmonary veins, aorta, and pulmonary artery.

After removal of the heart from the body it is to be further examined with reference to its valves, cavities, muscular substance, and blood-vessels. Remove all clots from the pulmonary artery and aorta, hold the heart vertically by seizing in turn the walls of each of these vessels, and allow water to run into them from above. Note whether each of these vessels "holds" the water, or whether it escapes—if the former, the valves are sufficient; if not, they are insufficient, and an idea of the degree of insufficiency may be obtained by noting the rapidity with which the water escapes.

The ventricles are now to be further opened—the right by a cut beginning at the lower end of the incision already made and carried upward to and through the pulmonary artery; the left by continuing the incision already made directly upward into the aorta, between the left auricular appendage on the right and the pulmonary artery on the left.

Opportunity is now afforded for an examination of the cusps of the aortic and pulmonic valves. Having completed this, insert as many fingers as possible into the mitral and tricuspid orifices. Normally the mitral admits three, the tricuspid four. Next examine the segments of these valves and their chordæ tendineæ.

Note the size and shape of the cavities of the ventricles. Continue the incisions already made in the auricles into the auricular appendages as far as the tips, noting the size of the auricles and whether thrombi are present in the appendages. Next examine the muscular wall of the heart and the papillary muscles with reference to thickness, color, and consistency. Follow out the coronary arteries as far as possible, with the probe-pointed scissors, with reference to narrowing of lumen from endarteritis or to presence of emboli or thrombi. This completes the examination of the heart.

The lungs and pleuræ next deserve attention.

In the previous cursory examination of the pleural cavities with reference to the presence of fluid, the presence or absence of adhesions of the pleural surfaces, over a larger or smaller area, was also probably noticed. If there be any adhesions they should now be torn. If the two surfaces are so adherent that they cannot be separated except at the risk of injuring the lung, the costal pleura should be removed with the parietal pleura and lung, by first cutting the pleura along the under surface of the ribs near the anterior border, then inserting the fingernails, and then the fingers, and tearing it away from the costal wall.

The left lung is now removed by lifting it out of the pleural cavity and supporting it with the left hand in such a way that the primary bronchus comes in the fork between the middle and ring fingers. The bronchus should now be cut across, and the small amount of connective tissue of the posterior mediastinum which supports the lung behind should be divided with the knife, keeping close to the lung to avoid injuring the œsophagus, which lies beneath.

Remove the right lung in the same way. Note the volume of the lungs, the density, whether crepitant or whether in part or wholly solidified. Also note whether

or not there are false membranes upon the pleuræ. The incision into the lung is to be made by resting the organ on its base, then making a sweeping cut from apex to base in the direction of the bronchus, beginning on the convex surface and carrying it sufficiently deep to open the bronchus. This gives two large surfaces for examination. The bronchi are now to be opened with the scissors, to the smallest tubes in which the blade of the scissors will go. If there be any evidence of embolism in the lung the branches of the pulmonary artery should also be followed out.

Next examine the bronchial lymph-glands.

This completes the examination of the thoracic cavity for the present, and attention should be turned to the abdominal cavity. The method to be given for its examination is the one to be followed out in case there is no evidence of there having been an acute peritonitis. The variation in the method in this circumstance will be described later.

The spleen is to be removed first. It should be seized in the left hand and drawn outward and upward from its position, then lifted upward above the lower margin of the ribs. In this way the gastro-splenic omentum is put upon the stretch and can be readily divided, together with the splenic vessels at the hilus. The organ is now free. Its size, shape, color, and density, together with the appearance of the capsule, should be noted. An incision is then to be made into it parallel to its flat surface. The follicles, trabeculæ, and pulp are the individual parts in the cut surface that demand attention.

The intestines are now to be removed. Lift up the omentum, examine it, then cut away its attachments to the transverse colon. Next separate the transverse colon from the stomach by dividing the two folds of lesser omentum which unite them. Then draw the small intestines over to the right; by so doing the descending colon will be exposed. It should be seized, lifted upward, and its meso-colon divided close to the intestine. The sigmoid flexure is to be freed next, and the rectum cut across a little below the brim of the pelvis. The folds of small intestine are now carried over to the left half of the abdominal cavity so as to uncover the ascending colon. The dissection to remove this should be begun at the hepatic flexure, freeing it from the surrounding parts, using special care not to injure the duodenum, which lies in contact with the ascending colon in its upper posterior portion. Continue the dissection until the cæcum is reached, which can be removed with the vermiform appendix by first cutting the peritoneum that binds it down laterally, and later the loose connective tissue that holds it down posteriorly. The large intestine is now free.

The small intestine is to be freed from its mesentery by cutting the latter close to its attachment to the intestine. This is best acomplished by making traction on the intestine, thereby rendering the mesentery tense, which can then be readily and rapidly divided by a series of fiddle-bow-motion cuts made with the large knife. The separation of the intestine from the mesentery should be continued until the point is reached where the jejunum passes behind the peritoneum.

At this stage in the autopsy the duodenum is to be opened *in situ* by an incision made with the scissors along the outer, convex border. This is done that the common bile-duct and its orifice may be examined—a point of the first importance in cases of jaundice, for determining the cause. The orifice of the duct forms a papilla situated on the pancreatic side of the duodenum about the middle of the descending portion and directly opposite the incision already made. The bile-duct, in the latter part of its course, lies beneath the mucosa of the duodenum. This portion of the duct should be pressed upon by the finger, and the latter moved toward the orifice, which is to be watched with reference to the expulsion from it of bile or a plug of mucus. Pressure may now be applied to the gall-bladder, and the appearance or non-appearance of bile at the orifice be noted. If no bile flows the common duct should be opened with the fine, probe-pointed scissors and the cause of the obstruction sought. It may be a plug of mucus formed as the result of an inflammatory process extending to the duct in a case of gastro-duodenal catarrh, or it may be a biliary calculus.

The stomach, connected with the intestine, together with the pancreas and mesentery, are now to be removed. To do this the left lobe of the liver should be lifted up; the diaphragm cut through its middle as far down as the œsophagus; the œsophagus divided transversely about two inches above the stomach; the cut end compressed between the thumb and forefinger of the left hand; the stomach lifted and dissected away from the underlying tissues; the pancreas and mesentery dissected from the aorta and inferior cava, and the gastro-hepatic and duodeno-hepatic omenta divided. The whole gastro-intestinal tract, together with pancreas and mesentery, is now freed and can be removed from the body.

Although the examination of the intestines is usually postponed until the last, to avoid soiling other parts with its contents, yet the method will be given here. The gastro-intestinal tract should be opened its entire length, either with an ordinary pair of scissors or with an instrument which renders the operation far easier, the enterotome (Fig. 3045), the hooked blade being introduced into the inside. The stomach is to be opened along the greater curvature, the reason being that the common lesions—ulcers—are usually situated on the lesser curvature. The small intestine should be opened along the mesenteric attachment, for the reason that Peyer's patches, the usual seat of typhoid and tubercular processes, are situated on the opposite side. The large intestine is to be opened along one of the three tæniæ, or bands, the object being to avoid getting the point of the scissors caught in the pouches lying between the bands.

Much time can be saved by using the scissors, not in the ordinary way by opening and closing the blades, but by keeping the blades immovable and carrying the scissors forward with the right hand, at the same time drawing the intestine backward with the left hand.

The amount and character of the contents of the various portions of the gastro-intestinal tract should be noted; the mucosa is to be freed of its adherent material either by water, where this can be obtained, or else by the fingers, and the mucosa of the entire tract is then to be carefully examined for evidences of inflammatory processes—ulcers, perforations, or other lesions.

The stomach and intestines having been removed from the abdominal cavity, a view can be obtained of the kidneys, ureters, and bladder *in situ*—a point of value, as the relation of one to the others is often needed in explaining the association of lesions. It is the custom of the German pathological anatomists to remove the kidneys before the intestine, hence at a stage in the autopsy when it is impossible to get a view of the urinary tract in its continuity. It seems to the writer that nothing is gained by removing the kidneys before the intestine, but that much may be lost; for if one finds, as the kidneys lie *in situ*, that they present changes, it may be very advantageous to remove them with the renal artery and aorta, on the one hand, as in cases of atrophy, especially when dependent upon a chronic interstitial nephritis, or, on the other hand, with the ureters and bladder and perhaps the penis, if there be hydro-nephrosis or pyelo-nephritis.

A general inspection of the urinary tract having been made as the parts lie *in situ*, one should then open the bladder by an incision one to two inches in length along its upper wall. The amount and character of the contents, and especially the appearance of the mucous membrane, should be noted; for if there be evidence of an inflammatory process it will be desirable to remove the kidneys, ureters, and bladder in a single mass, owing to the fact that inflammatory processes in the mucosa of the bladder may extend upward through the ureters and involve the pelves of the kidneys and the kidneys themselves.

If there be no evidence of a cystitis, no further examination of the bladder is now to be made, but attention is to be directed to the kidneys. Inasmuch as the kidneys

lie behind the peritoneum, it is necessary to cut this in order to get at them. The incision should be made just to the outside of the kidney along its convex border. The fingers of the right hand should now be introduced into the cut and the kidney "shelled out" of its perinephritic fat, lifted upward, the blood-vessels at the hilus cut transversely and traction made upon the kidney, which will strip up the ureter as far as the brim of the pelvis, where it may be divided. The supra-renal capsules may either be removed with the kidney or may be left *in situ* until a later stage of the examination. On the right side it is less easy to remove the supra renal capsule with the kidney than on the left, owing to its closer adhesion to the under surface of the liver.

The examination of the kidney consists in noting its size, shape, color, and density; removal of capsule, observing whether it comes off easily or with difficulty, also whether portions of renal substance adhere to it. An incision in the kidney is made by holding the organ between the thumb and fingers of the left hand, with the hilus resting upon the palm, and cutting along the whole convex border through the kidney to and into its pelvis. In the examination of the cut surface the ratio of cortex to pyramids, as to thickness, should first be noted, and then the cortex studied with reference to the appearance presented by the glomeruli and the regions of convoluted and straight tubules. The degree of injection of the vessels of cortex and pyramids, as determined by the color, is to be observed; then the mucous membrane of the pelves examined; finally, the ureters are to be opened. If there be evidence of atrophy involving one or both kidneys, the corresponding renal artery should be opened to the aorta to determine whether the lumen is narrowed from chronic endarteritis.

The next step in the autopsy is the removal of the pelvic organs, either with or without the external genitals. In the female, the external genitals should be removed with the internal genitals in cases of death following puerperal fever or abortion; in the male, when there is a suspicion of stricture or wound of the urethra, or of a periurethral abscess.

In case it is not necessary to remove the external genitals the method of procedure for removal of the pelvic organs is as follows: Sweep the knife around the true pelvis, keeping as close to the bony wall as possible; in this way the loose connective tissues will be severed. Seize the bladder by its upper portion and draw it backward, away from the pubes; cut its attachments to the pubes, and then, while still making strong backward traction, cut the vagina and rectum transversely as far forward as possible. In this way the vagina as far as the hymen may be obtained. The same procedure, so far as the drawing back of the bladder and cutting its attachments is concerned, is to be carried out in the male, the prostate and rectum being then divided transversely as far forward as possible.

The removal of the external genitals connected with the internal pelvic organs is accomplished in the following way: The pelvic organs are freed from their surroundings as already described; then incisions are made on the outside, beginning at the lower end of the primary incision, which had been carried to the pubes, and carried to the outside of the labia majora on both sides in the form of an ellipse, the two cuts meeting again in the median line behind the anus at the tip of the coccyx.

The vulva is now dissected away from the pubes until the bony pubic arch is reached. The knife is then to be inserted beneath the pubic arch with the blade close to the bone, and then pushed into the cavity of the pelvis so that its point can be seen. With the knife held horizontally, it is swept around in the two curved incisions described above until the coccyx is reached. This will free the attachments to the pubic arch anteriorly and laterally, and to the coccyx and lower part of sacrum posteriorly.

The external genitals are now to be drawn under the pubic arch into the cavity of the pelvis. This puts the attachments to the sacrum on the stretch, and gives a better view of the parts that still require to be divided in order to wholly free the organs in question.

In the male the penis may be removed with the internal organs, by drawing the dartos toward the glans; cutting with the scissors the small amount of connective tissue that holds the skin to the body of the penis; then dividing the penis by a transverse cut just behind the corona, unless it is thought desirable to remove the glans also, in which case the dartos should be cut circularly where it is reflected upon the glans, *i.e.*, in the corona. The attachments of the penis to the pubic arch are divided by transfixion, as in the female; the organ is drawn under the arch into the cavity of the pelvis, and the adhesions to surrounding parts divided.

If there be anything abnormal about the perineum, it is desirable to remove with the penis and pelvic organs an elliptical or lozenge-shaped portion of skin, its anterior apex being just behind the scrotum, having its posterior apex at the coccyx. This will include perineum and anus. The removal is accomplished by transfixing with the knife held in a horizontal position, the point being carried well into the pelvic cavity.

The further examination of the male pelvic organs consists in prolonging the incision, made in the bladder while *in situ*, to the urethra through the prostate with the scissors. If the penis has been removed, the incision should be continued along the dorsum to the meatus. The interior of the bladder and urethra can now be examined. Transverse incisions are to be made in the prostate. The vesiculæ seminales and the prostatic and vesical venous plexuses should next receive attention. The plexuses are of importance, as likely to be the seat of thrombi.

The rectum is now to be opened along its posterior wall, and the mucous surface examined.

In the female the bladder and urethra are first to be opened and examined. The vagina is then to be exposed along its whole length by an incision along its left lateral wall. In this way one avoids injuring the bladder. When the cervix is reached, the incision should be carried at right angles to its first direction, and the anterior wall of the vagina be cut transversely as far as the middle line of the uterus. The scissors are then introduced through the os into the cervical canal, and the uterus opened by cutting in the middle line anteriorly as far as the fundus. Counter-incisions, beginning at about the middle of the body, are now to be made in the direction of the orifice of each Fallopian tube.

If the tubes are enlarged they should be opened with the probe-pointed scissors. In the normal tube the canal is so small that it is almost impossible to follow it out, and it is furthermore unnecessary.

The ovaries are to be opened by an incision beginning on the free, convex border and continued to the hilus, *i.e.*, to the broad ligament. The vaginal and uterine plexuses are then to be examined.

If death has occurred in the puerperal state or after an abortion, the external genitals and vagina should be examined carefully with reference to lacerations, and numerous incisions be made in the vaginal wall, extending into the perivaginal connective tissue, to determine whether a purulent lymphangitis is present.

In the puerperal uterus the inner surface is to be examined for evidence of an endometritis. The uterine sinuses, the pampiniform plexuses, and the ovarian veins are to be examined for thrombi undergoing septic softening. The tubes are to be opened to discover evidence of a purulent inflammation of their mucosa (salpingitis purulenta). Numerous incisions are to be made in the wall of the uterus for evidence of suppurative lymphangitis.

The examination of the testicles can be readily made, without injuring the scrotum, by pushing them upward through the canal, so that they will appear at the rings on either side. The peritoneum and then the tunica vaginalis are to be divided, and the testicle can be removed by severing the cord. It should be opened by an incision parallel to its long diameter, beginning on the side opposite the epididymis.

The liver is removed by cutting the ligaments. In

noting the size of this organ one should take cognizance of the relative size of the right to the left lobe. The shape, color, density, and any points relating to the capsule are to be observed. The incision for examining the interior should be made transversely, beginning at the left border and ending at the right border. The appearances of the single lobules are now to be studied; the relative proportion of central and peripheral parts and the color of each being the important points to be observed.

The gall-bladder is to be opened by an incision parallel to the long diameter.

The order in the examination of the organs of the abdominal cavity is to be varied in case of acute peritonitis. In making an autopsy one should not rest satisfied in finding evidence of acute peritonitis, but should always search for the cause. Of the causes, the most common are extension of an inflammation from the pelvic organs, especially in the female; perforation of the vermiform appendix from appendicitis; and perforation of the gastro-intestinal tract at some part. In case of acute peritonitis no organ should be removed until the *probable* source has been made out. This is done by lifting and separating the folds of intestine, and observing in which part of the peritoneal cavity the inflammatory process is farthest advanced. Then the parts may be dissected away from this organ, whichever it may be, and the attempt made to find the perforation or other lesion which is primary. The questionable organ may then be removed and further examined.

To proceed with the method ordinarily carried out. After the removal of the liver there remain in the cavity of the chest and abdomen the trachea and its bifurcation, the greater part of the œsophagus, the aorta, and the inferior cava. The aorta is to be opened *in situ*, with the scissors, along the anterior wall from the arch to the bifurcation, and then the iliac arteries are to be opened to the groin. The inferior cava and the iliac veins are also to be opened. These vessels are opened *in situ* that no injury may be done to thrombi if they be present within.

The aorta and as much of the trachea and œsophagus as possible are now to be removed by cutting the two latter as high up in the neck as they can be reached, and dissecting them and the aorta from the vertebral column, the aorta being attached to the vertebral column by a small amount of connective tissue.

The trachea is to be opened along its posterior wall (the cartilaginous rings being interrupted at this part); the œsophagus along the anterior wall.

The larynx and tongue may be removed with the lungs, or simply with the trachea. The knife is passed upward under the skin of the neck and the attachments of the trachea and larynx to the anterior, lateral, and posterior parts severed by sweeping cuts starting in the median line and carried to the side and then to the back. The attachments of the muscles of the tongue to the lower jaw are divided, the knife being carried up from below preferably to being introduced through the mouth. The soft palate is separated from the hard palate, and the pillars of the fauces are cut laterally so as to include the tonsils. The tongue is now seized with the fingers of the left hand passed upward through the neck and drawn downward, and the muscles and connective tissue holding the pharynx to the vertebral column are divided.

In this way the soft palate, tonsils, wall of pharynx, larynx, and upper part of œsophagus may be removed together, and a good opportunity afforded for their examination—a point of value in diphtheritic processes and the like.

The larynx should always be opened anteriorly.

The cavity of the trunk is now empty and a good opportunity is afforded for the examination of the bodies of the vertebræ, if there be anything in the case which renders such an examination desirable.

Unless the brain or cord is to be removed, the examination is now completed. Before returning the organs to the body-cavity it should be sponged dry, and the pelvis packed with pieces of old cotton cloth to prevent leakage through the anus. After the organs have been put back the sternum is to be replaced and held by two stitches on either side, taken through the intercostal muscles.

The flaps are next brought into apposition preparatory to sewing them together. To do this take a piece of stout twine one and a half time the length of the incision; after threading it, take a stitch at the extremity of the long incision and tie a hard knot in the end of the string. For sewing, the glover's stitch is to be used, *i.e.*, from inside out. The stitches should be about three-quarters of an inch apart and three-eighths of an inch from the edge of the flap, taking up only the skin and subcutaneous tissue, but not the fat-tissue. When the seam is finished a double knot is made in the string and the end drawn under the skin.

Certain final details will be considered after the method of removal of brain and cord has been explained.

Method of Removal and Examination of the Brain.—Note the ratio of the head to the body, and of the cranium to the face.

Make an incision in the scalp, beginning half an inch behind the right ear, near its lower border, and extending over the middle of the vertex to the corresponding point behind the left ear. In women the hair should first be roughly parted, along the line where the incision is to be made, with the handle of the scalpel. After the incision has been started by cutting with the edge of the knife downward, it is best to reverse the blade so that its back comes against the bone and to cut upward. The incision is to be carried to the bone except in the temporal region, where it should be carried only to the aponeurosis covering the temporal muscle.

The anterior flap is first to be freed from the temporal muscle on either side, leaving the muscle attached to the bone, as it is through this that the stitches will be taken later that are to hold the calvaria in place. The flap is now to be seized by the left hand and strong forward traction made, while a series of sweeping cuts through the pericranial connective tissue are made with the scalpel held in the right hand. This dissection should be continued until the frontal eminences come into view. The posterior flap of the scalp is now to be dissected from the bone as far back as the occipital protuberance. While the scalp is being removed the condition of the loose pericranial tissues should be noticed with reference to evidence of œdema, hæmorrhage, or purulent inflammation. The skull is now bare over the vertex, and note should be made of any abnormalities of its surface.

The next step is the removal of the calvaria. This is sometimes done by sawing through the skull in a circle; but this is bad practice, in that the calvaria cannot be later held firmly in place when it is sewn up—it will wobble. The best way is to saw along three lines to be marked in the periosteum, as a guide, with the scalpel. The first or anterior cut begins above and behind the ear, and is carried directly over the vertex to a corresponding point on the other side, the line passing just behind the edge of the hair above the forehead. The other two incisions in the bone are to begin, one at each end of the cut just described, and be carried backward to the median line behind, the two lines meeting at an angle of about one hundred and sixty degrees, well in front of the occipital protuberance. Each of these two lines just described should meet the anterior line at an obtuse angle in the temporal region.

If the hair be long it should be wrapped up in a towel, so as to form a ball, and the whole mass placed beneath the nape of the neck. This is to prevent the sawdust getting into it.

The calvaria is now to be sawn along the lines already marked, the head being steadied by placing the left hand upon the calvaria; a towel placed between the hand and the bone prevents slipping.

The incision in the bone should be carried through the outer table and diploë, and nearly through the inner table. One can readily determine when the saw has reached the diploë by the red color of the sawdust and the softer feel conveyed to the hand through the saw-

blade. What remains unsawn can be readily cracked with the chisel and hammer, placing the chisel in the incision and striking with the hammer a quick, sharp blow known as a recoil blow; this obviates the danger of driving the chisel into the brain.

If there be a suspicion of fracture of the skull, the incision with the saw should be carried through the bone and no cracking whatever done with the chisel and hammer.

The calvaria being now loosened, the wedge-shaped end of the hammer head is to be introduced in the middle of the anterior cut and pressed downward with the left hand, while the handle is rotated in the horizontal plane with the right hand. In this way a powerful leverage is obtained, and the calvaria can be forced backward sufficiently to introduce the hook on the end of the hammer handle into the cut in the bone. By pulling backward on the hammer the calvaria may be separated from the dura and so removed.

Generally the adhesion between the calvaria and dura is not a firm one, but occasionally in adults the separation requires the aid of the end of the enterotome, introduced between the dura and the bone and the two pried apart. Occasionally in old people, and always in young children, the adhesion is so firm that the dura has to be removed with the bone. This is accomplished by incising the dura along the incision in the bone and then cutting the attachment of the falx to the crista galli in the superior longitudinal fissure, when the calvaria may be drawn backward and the falx cut posteriorly.

After the removal of the calvaria, its thickness, the relation of diploë to tables, and the appearance of the inner surface should be noticed.

The examination of the dura is now in order. First observe whether the alternation of fissures and convolutions, as darker and lighter areas lying beneath, can be determined through it. If so, the dura has the normal degree of translucency, and is of the normal thickness. If this alternation of dark and light cannot be made out the dura is thicker than normal. Next open the superior longitudinal sinus and note its contents, whether fluid or coagulated blood or a thrombus. With scissors and forceps cut through the dura along the line of incision in the bone; then reflect it toward the median line so as to expose its inner surface. The presence of haemorrhagic or pigmented false membranes or patches is the important pathological condition to be looked for here.

The knife is now to be introduced into the superior longitudinal fissure, the dura drawn backward, and the attachment of the falx to the crista galli severed. The dura can now be drawn backward as far as the posterior incision in the skull; it should not be cut off, but should be allowed to hang down. The veins of the pia, where they enter the superior longitudinal sinus, offer slight resistance to the removal of the dura. They may be divided with the knife or scissors or else torn.

The greater portion of the convexities of the brain is now in view. One should note, in connection with the pia, the degree of fulness of its blood-vessels; whether it is translucent or opaque; whether abnormally dry; whether its meshes contain clear serous fluid, and, if so, the amount; also whether there be fibrin or pus in its meshes. One should then note whether the brain fills the cavity of the skull; also the relation of the convolutions to the sulci as to proportionate size.

The brain is now to be removed from the skull. Insert the two forefingers between the dura and the frontal lobes on either side of the median fissure and hook them around these lobes; draw backward on the brain until the optic nerves can be seen; then making slight traction backward on the brain by two fingers of the left hand hooked around its tip, cut across the cranial nerves and carotid arteries close to their foramina until the tentorium is reached; cut the latter close to its attachment to the petrous portion of the temporal bone. Next divide the cranial nerves given off from the medulla oblongata. Then carry the knife as far down in the vertebral canal as possible, and cut the cord by an inverted V-shaped cut, starting in the median line, and cutting first to the right, then to the left. The vertebral arteries are divided by the same stroke.

The brain is now readily removed by hooking the fingers of the right hand under the cerebellum, supporting the brain from behind with the left hand, and then lifting it out by the same turn employed in delivering the aftercoming head in a breech presentation.

The further examination of the brain is to be postponed until the basal portion of the cranial cavity has been looked at. The lateral sinuses are to be opened and their contents noted. If there be a suspicion of a fracture the whole of the dura is to be stripped off, it being usually impossible to discover a fracture of the base while the dura is *in situ*.

The posterior part of the eye may be exposed and removed by chipping away with the chisel the thin orbital plate which forms the roof of the orbit and the greater part of the floor of the anterior fossa.

The middle ear can be exposed by chipping off its roof, which lies in the middle of the petrous portion of the temporal bone. If the inner ear is to be examined, the whole petrous bone must be sawn out by a V-shaped incision in the squamous portion of the temporal, the apex of the V extending below the external meatus.

The mastoid cells can be opened either from the inside of the skull or from the outside.

An excellent view of the nares can be obtained by removing those portions of the ethmoid and sphenoid lying in the middle line, from the cribriform plate of the ethmoid in front to the posterior clinoid processes behind.

By removing the basilar process of the sphenoid and the sphenoidal process of the basilar, the so-called clivus Blumbachii, an excellent view of the pharynx and larynx can be obtained.

The examination of the brain is now to be resumed. If it is desired to weigh it, this should be done before it is incised. The brain is placed upon the convexities, the base uppermost. The pia of the base is to be examined especially for evidence of inflammation or tuberculosis. The blood-vessels should then receive careful attention —first the circle of Willis, then the vertebrals and basilar, then the anterior cerebrals. The fissure of Sylvius is now to be opened by cutting the pia that forms a bridge across the fissure from the frontal to the temporal lobes, and the branches of the middle cerebrals followed out as far as the island of Reil. These are the most important of the cerebral vessels, owing to the liability of lodgement of emboli in them and because they supply the larger and most important part of the brain. Evidences of endarteritis should be looked for, and the vessels opened with the probe-pointed scissors. Emboli or thrombi, if present, can now be readily discovered.

This examination completed, the brain should be placed upon its base and the incisions made to open the lateral ventricles. This is a curved incision following the direction of the ventricle, the convexity being inward, the anterior end about the middle of the frontal lobe, the posterior end near the middle of the occipital lobe, the middle of the curve about a quarter of an inch from the longitudinal fissure. The hemisphere should be supported by placing the fingers of the left hand under the base and the thumb of the same hand in the longitudinal fissure, lifting the hemisphere upward. This serves to separate the roof from the floor of the ventricle.

The anterior portion of the cut should be deep, made with the knife held at an angle of forty-five degrees, point downward (to reach the anterior horn). The middle portion of the cut should be less deep, made with the knife held horizontally (so as not to injure the floor of the ventricle). The posterior cut should be deep, made with knife held at an angle of forty-five degrees, handle downward (to reach the posterior horn).

One lateral ventricle having been opened, the brain is to be turned half around and the other lateral ventricle opened in the same way. The knife is now introduced in the foramen of Munro, and an incision is made vertically upward through the anterior pillars of the fornix and the corpus callosum. The posterior portions of the fornix and corpus callosum are now drawn backward as far as pos-

sible. By so doing the velum interpositum and choroid plexuses are brought into view. These are also to be drawn backward, thus exposing the third ventricle. The right posterior pillar of the fornix and the adjoining brain-substance are now cut transversely and carried over to the left. This procedure exposes the corpora quadrigemina. The fourth ventricle is now to be opened by an incision made through the middle line of the cerebellum, from above downward, at the same time dividing the corpora quadrigemina and valve of Vieussens by extending the median cut to the aqueduct of Sylvius.

The whole ventricular tract is now exposed to view. Note should be taken of the size of the ventricles, the character and amount of their contents, and the condition of the ependyma.

The hemispheres are next examined. In doing this it is essential to expose as large an area of white and gray matter as possible, but without disturbing the relations of the parts. The first incision is a curved one just to the outside of the basal ganglia and following the line of their outer borders. It should extend nearly to the pia below. A series of cuts are now to be made, each succeeding cut being made in the middle of the preceding cut and extending to, or nearly to, the pia. In this way the hemisphere is rolled out, unfolded as it were, and a large surface or series of surfaces is exposed to view. The pia is to be left uninjured, serving as a binding to retain the parts in their normal relation; so that, if a lesion be discovered in the white or gray matter, the parts may be replaced and the situation localized as to convolution.

The basal ganglia (corpora striata and thalami optici) are now to be examined by means of a series of transverse incisions, the cuts being about one-twelfth of an inch apart. These are most readily made by supporting the ganglia by one hand placed underneath, while with the knife in the other hand the cuts are made and the slices turned to one side so as to expose the cut surface. The necessity of the numerous incisions in the basal ganglia is owing to the fact that lesions sufficient to lead to a fatal result are often small, and might go unobserved were the incisions made far apart.

The cerebellum is now to be examined by a primary incision beginning in the middle of the cut made in it in opening the fourth ventricle and extending through the greatest breadth of the organ. This divides it into two equal portions, exposing a large surface of gray and white matter and the arbor vitæ. A series of radiating, fan-shaped incisions should then be made in each of these lateral portions, the cuts extending to the pia.

The pons is now to be lifted by the left hand placed beneath it and a series of transverse incisions is to be made, beginning anteriorly in the corpora quadrigemina and crura cerebri and extending through pons and medulla to the spinal cord. As in the basal ganglia, so here, the slices should be as thin as possible, that even a minute lesion may not escape observation.

The remaining step in the examination of the brain is to strip the pia from the convolutions of the organ, especially on the convexities, and note whether it is readily removed or whether it comes away with difficulty and removes portions of brain-substance with it, leaving a worm-eaten appearance of the cortex beneath. Such an adhesion indicates a meningo-encephalitis, common in dementia paralytica.

The examination of the brain being now completed, the cavity of the cranium should be sponged dry and filled with a sand-bag, made by taking a piece of cotton cloth eighteen inches square and putting on it as much house-sand as corresponds, in the judgment of the operator, to the capacity of the cranium; then gathering the corners into a mass and tying them together with a string. A sand-bag serves the double purpose of giving weight to the head and supporting the calvaria. The calvaria is to be replaced and held there by stitches taken through the temporal muscle on either side, care being taken to draw the twine tight to prevent slipping of the calvaria. The two flaps of the scalp are now drawn together and sewn, after the method described in connection with the body. The seam requires a piece of twine twice the length of the incision.

Examination of the Spinal Cord.—To remove the cord the body should be placed face downward, with a block under the thorax. An incision is made along the ridge formed by the spinous processes of the vertebræ from the occiput to the sacrum. The skin together with the muscles filling the vertebral grooves should be dissected from the arches, leaving the laminæ bare. The laminæ are now sawn nearly through in a line with the roots of the transverse process. By means of the straight chisel or, better, with the rachitome (Fig. 3049) and the hammer the arches are freed and then pried off. The arches of the upper cervical vertebræ are best divided with the costotome (Fig. 3044).

The membranes and cord are now divided transversely at the lower end; the dura is seized with the forceps and the cord lifted upward, and the spinal nerves are divided with the scalpel close to the foramina. When the atlas is reached the cord is held only by the dura where it is reflected on the margin of the foramen magnum to become the periosteum of the inner surface of the skull. This is divided by a circular incision a little below the foramen magnum. The cord is now free.

The dura of the cord is now incised anteriorly and posteriorly throughout its entire length, and its inner surface, as well as the pia of the cord, examined.

The cord is examined by a series of transverse incisions half an inch apart, the pia on the anterior surface being left intact to serve as a binding to hold the parts together.

If it is desired to preserve the cord or portions of brain for microscopic examination, they may be hardened in what is known as Mueller's fluid. The formula for this is:

Bichromate of potash	2.5
Sulphate of soda	1.0
Water	100.0

Portions of the brain, not larger than a cubic inch, preferably smaller, and the cord should be immersed in this fluid; a cord requiring a quart. They should be left for six weeks, changing the fluid if it becomes cloudy; then washed in running water for three days; then placed in strong alcohol, in which they will keep indefinitely. Inasmuch as the post-mortem changes take place with rapidity in nerve-tissue, it is desirable to put the portions intended for microscopic examination into the preserving fluid as early as possible.

The incision in the back is to be sewn up in the same way as the one in front.

The examination of the whole body being now completed, the soiled newspapers are to be removed and burned in the furnace or kitchen fire. The operator should himself attend to the emptying of the slop-pail, which will contain bloody fluid and more or less intestinal contents; and should also see that all utensils are thoroughly cleaned, that all spots of blood are removed from the body, and that the body is restored to the position it was in before the autopsy was begun.

A word as to the report of the autopsy. A proper report should consist of two parts. The first, to consist of a description of what is seen, should be purely objective, and should contain no expression of opinion. The second part is to contain the anatomical diagnosis; in other words, the inferences drawn from the appearances presented by the organs.

If the report consists (as unfortunately it so often does) simply of the inferences of the operator, without a description of the appearances upon which those inferences are based, it is of little value to anyone else, and of no value as evidence.

Let the physician, then, in his report, describe to the best of his ability what he sees, and if he is in doubt as to what the meaning of the appearances is, any specialist taking his report can give him much more assistance than if the inferences only are stated.

W. W. Gannett.

POST-MORTEM EXAMINATIONS, LAW OF. The medical examination of dead bodies is authorized by most civilized communities in the interests of justice and science; but such examinations must be conducted under the forms of law, or otherwise the examiners will be liable in heavy damages, and subject also to criminal penalties.

The examinations are usually conducted by officials called coroners, according to regulations expressly enacted for them.

A body can also be exhumed and examined, by dissection or otherwise, upon the order of a court of ordinary jurisdiction, when such examination is necessary to prove the innocence or guilt of persons on trial.

The examinations conducted by coroners may or may not be accompanied by a dissection, according as the necessities of the case require.

It is the object of the examination to ascertain whether the death was a violent one or not, and whatever is requisite to this end is allowable.

Inquests can be held upon the bodies of persons dying from criminal violence, or by casualty, or in apparent health, or when unattended by a physician, or in prison, or in any suspicious or unusual manner.

Coroners cannot, however, hold inquests at their pleasure, without sufficient cause, for the purpose of securing fees or for any other reason.

The privacy of homes cannot be invaded by a coroner except upon good and sufficient grounds, and he would be liable in damages for an improper intrusion.

The procedure in large cities and in the country-districts is generally somewhat different. In New York City the Board of Health has jurisdiction to see that inquests are not conducted in a manner prejudicial to health, and the body can be removed by order of the Board when a private person would have no right to touch it.

In case of an inquest by a coroner without probable cause, he cannot recover any fees for his services.

Citizens are required to report to the coroners or the police the fact of any death under suspicious circumstances known to them, and if they do not, they are guilty of a misdemeanor, and can be punished either by fine or imprisonment, or by both fine and imprisonment.

Inquests can be conducted by coroners with the aid of a jury, which is usually constituted of not less than nine, and not more than fifteen, persons.

The inquest cannot proceed without the dead body being viewed by the jury and the coroner together, and it must be exhumed if already buried.

The further proceedings need not, however, be conducted in the presence of the corpse.

A competent physician or surgeon can be employed by the coroner to perform an autopsy, and when there is no official whose regular duty it is to perform autopsies, an employment by the coroner will make the county liable for a reasonable fee.

The testimony of such an expert and of the other witnesses constitutes the inquest.

The coroner can issue subpœnas to compel the attendance of witnesses.

The verdict rendered upon the inquest should be in writing and be signed. It should set forth who the dead person is, when, where, and by what means the death occurred, whether by the act of another or by criminal means, and who is guilty, so far as these facts can be ascertained.

The jury need not be unanimous, and two different verdicts can be rendered if the jurors differ in their opinions.

When a coroner is lawfully holding an inquest he can order the dead body to be examined or dissected for the purpose of ascertaining the above-mentioned facts, but no further.

Such post-mortem examination is not a public matter, and does not entitle citizens to demand to be admitted; and the suspected person or his friends cannot make such a demand and they cannot have an expert of their own choosing to assist at the autopsy.

The examination before the coroner is public, however, and anyone is entitled to be present. The testimony should be legal testimony and taken in a legal manner, and the suspected person may be examined.

The jury, when deliberating upon their verdict, should be kept by themselves, like other juries, and the coroner is not to be present.

When the verdict charges a certain person with causing the death, the coroner can issue a warrant for his arrest.

The records kept by coroners and the proceedings upon inquests are public property, and are open to the examination of anyone. *Henry A. Riley.*

POTASSIUM. I. General Medicinal Properties of Compounds of Potassium.—In its physiological relations potassium is the most individual of the alkali metals, producing effects sufficiently pronounced to be characteristically seen in the case of all its compounds that are capable of absorption. Such effects are as follows: Locally, potassic compounds are irritant—less so than the average of soluble compounds of the heavy metals, but yet sufficiently so to make a large portion of a strong solution of a potassic salt dangerous on the score of irritation alone. In the intestines, potassic salts tend to increase the secretion of fluid, so that salts of this base that are of low diffusion-power prove watery purges. Constitutionally, the prominent effects are certain derangements of function and certain effects that find their simplest explanation in the assumption that potassium quickens the rate of oxidation within the organism as it does in laboratory experiments. The derangements of function are, first, an enfeeblement of the heart's action, passing, in poisonous dosage, to permanent arrest in diastole. The effect seems to be due, as results of all experimentation agree, to a directly paralyzing influence upon the musculature of the organ itself. Secondly, but requiring relatively larger dosage, there follows general motor paralysis, voluntary and reflex. This effect is proportionately much more strongly marked in cold-blooded than in warm-blooded animals, and in therapeutic dosage in man is practically not seen at all. It is probably accomplished by an action on nerve-centres, nerve-trunks, and muscles conjointly, but an action which is most intense upon the nerve-centres and least so upon the muscles.[1] The effects commonly assigned to a quickening of oxidation are, in the healthy, an increase in the solid excreta of the kidneys, with a proportionate increase in the volume of the urine, and, in the lithæmic individual, a diminution in the amount of uric acid excreted, with a simultaneous increase of urea and appearance of calcic oxalate. These effects in lithæmia are translated to mean an oxidation of much of the uric acid into oxaluric acid, which product then splits into urea and oxalic acid.[2] In large doses, long continued, potassic compounds prove noxious to nutrition, the blood becoming thin and unduly fluid, newly formed and lowly vitalized tissues, such as cheesy deposits, tending to liquefy, and health and strength generally to suffer. Therapeutically, the effects of applications of potassic compounds, determined by the potassium element of their composition, are to depress the heart in sthenic fever, to oppose the lithic diathesis, and to provoke catharsis or diuresis. Other uses are derived from individual peculiarities of the different compounds.

II. The Medicinally used Compounds of Potassium.—The compounds of potassium officinal in the U. S. Pharmacopœia divide, for purposes of study, into two groups—the one embracing compounds whose effects are either derived from the potassium or are *sui generis* to the salt, and the other such as owe their effects mainly to the acid radicle of their composition. The members of the former group, which alone will be discussed in this place, are the *hydroxide*, *carbonates* (normal and acid), *citrate*, *acetate*, *tartrates* (normal, acid, and potassio-sodic), *sulphate*, *nitrate*, and *chlorate*. The second category comprises the *hypophosphite*, *bromide*, *iodide*, *sulphide* (in the preparation, *potassa sulphurata*), *sulphite*, acid *chromate*,

cyanide, ferrocyanide, permanganate, arsenite (in the preparation, *liquor potassii arsenitis*), *potassio-aluminic sulphate* (alum), and *potassio-ferric tartrate*. For discussion of these compounds see, severally, Hypophosphites, Bromides, Iodides, Sulphides, Sulphites, Chromium, Cyanides, Ferrocyanides, Manganese, Arsenic, Aluminium, and Iron.

Potassic Hydroxide (Potassic Hydrate): KOH. This is the compound which is both commonly and officinally known as *Potassa*, Potassa, called also *caustic potash*. It is obtained first in an officinal five per cent. aqueous solution (*Liquor Potassæ*, Solution of Potassa), made by precipitating with lime a solution of acid potassic carbonate. Such aqueous solution, when rapidly boiled down, yields a fluid of oily consistence—simply the hydroxide melted by the heat—which, poured into cylindrical paper-moulds, hardens on cooling into the cylindrical sticks in which form potassa is commonly met with. Potassa, thus obtained, is a "white, hard, and dry solid, generally in the form of pencils, very deliquescent, odorless, or having a faint odor of lye, of a very acid and caustic taste, and a strongly alkaline reaction. Soluble in 0.5 part of water, and in two parts of alcohol at 15° C. (59° F.); very soluble in boiling water and in boiling alcohol. When heated nearly to a red heat, it melts, forming an oily liquid. At a strong red heat, it is slowly volatilized unchanged" (U. S. Ph.). Solution of potassa is a "clear, colorless liquid, odorless, having a very acrid and caustic taste, and a strongly alkaline reaction. Sp. gr. about 1.036" (U. S. Ph.).

Potassa produces physiological effects which spring in part from an intense affinity for water which the substance possesses, in part from its powerful alkalinity, and in part from its operation as a compound of potassium. Locally, in concentrated application, potassa is intensely caustic. A moistened stick swept even lightly over a tender surface produces speedy corrosion, which extends finally beyond the area of original application, the tissues breaking down widely into a brownish, slimy, pultaceous material. Taken internally, therefore, in strong solution, potassa is a corrosive poison. In such poisoning, the acrid, alkaline taste of the potion is followed immediately by severe pain in the pharynx, œsophagus, and epigastric region. These symptoms are in turn speedily succeeded by violent vomiting, where the ejecta have the greasy aspect and pultaceous consistency of tissues corroded by potassa, and prove strongly alkaline to test-paper. The mucous membrane of the lips, mouth, and throat may be bright red from irritation, if the solution swallowed were not overstrong, or may, in the case of strong potions, show direct corrosion, being covered by a brownish film having a greasy or soapy feel. Loss of voice and extreme difficulty of swallowing are exceedingly common, but intestinal symptoms are generally wanting. Constitutionally, the symptoms are those of shock, from the suddenness and severity of the corrosion. In survival from serious grades of the poisoning, stricture of the œsophagus is a very common sequel. In the treatment, the only peculiar feature is to give harmless acids to neutralize the alkali, but as the damage is generally already fully done before the physician arrives, this chemical neutralization rarely avails for much. Vinegar or lemon-juice are the acids most available, from their being strong but non-corrosive themselves, and at the same time readily procurable. Locally applied, in non-corrosive strength, potassa operates as a powerful and harsh alkali. Acids are neutralized, grease becomes saponified, epithelial tissues swell and soften, and acid secretions, such as the gastric juice and the sweat, tend to be called forth. Upon the skin, thus, potassa-lotions are cleansing of dirt or the crusts of dried secretion and epithelium resulting from skin-disease. Taken internally, the remedy locally excites appetite and increases the flow of the gastric digestive fluid, or, in cases of fermentation of the food, a dose, taken after such fermentation has occurred, neutralizes acidity and so relieves the heartburn and nausea which such acidity excites. Constitutionally, medicinal doses of potassa produce, of course, the effects of all potassium-compounds as already set forth, and also, because of free alkalinity, tend to neutralize morbidly developed acid in the blood or tissues, to diminish the acidity of the urine, or even to reverse the reaction of that secretion to alkaline. Probably in part because of the peculiar action of potassium as such, and partly because of the alkalinity of potassa, this compound is of special efficacy in the diatheses leading, severally, to rheumatism, gout, and lithæmia, and in the skin-diseases urticaria, psoriasis, eczema, lepra, acne, and recurring boils.

The medical uses of potassa are for the purposes above detailed, yet, except as a caustic, it is not so much used as its acknowledged potency would seem to suggest, simply because it is rough and harsh, while at the same time other and milder potassic compounds are medicinally equally efficient. Thus for direct local alkaline action the carbonates, and for constitutional alkalizing, the citrates and tartrates, are respectively preferable.

To *cauterize* with potassa, the adjacent parts should be protected by adhesive plaster, and the doomed area, if covered by skin, be rubbed with a moistened stick of the caustic until discoloration appears. If the part be a mucous membrane or raw tissue, a single light sweep of the caustic is sufficient for even a profound cauterization. In no case should the agent be used where an exact limitation of the caustic effect is essential, as where the part to be destroyed is in close contiguity to important, or large, blood-vessels or organs. To render the corrosion of potassa less spreading, a mixture of equal parts of potassa and quick-lime has been devised, and is officinal in the U. S. Pharmacopœia, under the title *Potassa cum Calce*, Potassa with Lime. This mixture, commonly known as *Vienna caustic*, takes the form of a "grayish-white powder, deliquescent, having a strongly alkaline reaction, and responding to the tests for calcium and potassium. It should be soluble in hydrochloric acid without leaving more than a small residue" (U. S. Ph.). In this preparation the peculiar action of lime renders less diffusive the operation of the potassa. For use the powder is made into a paste with a little alcohol.

For a potassa-lotion, the solution of the Pharmacopœia is to be prescribed, diluted with several volumes of water. For internal giving, the same solution is employable, in doses ranging from 0.65 to 4.00 Gm. (ten minims to a fluidrachm) greatly diluted with some sirupy or mucilaginous fluid. But potassa, as an internal remedy, is very objectionable for any but a very temporary medication.

Normal Potassic Carbonate: $(K_2CO_3)_2.3H_2O$. The salt is officinal in the U. S. Pharmacopœia under the title *Potasii Carbonas*, Carbonate of Potassium. It is a "white, crystalline, or granular powder, very deliquescent, odorless, having a strongly alkaline taste, and an alkaline reaction. Soluble in 1 part of water at 15° C. (59° F.), and in 0.7 part of boiling water; insoluble in alcohol. At a red heat the salt loses between fifteen and eighteen per cent. of its weight, and at a bright-red heat it melts. The aqueous solution strongly effervesces on the addition of acids, and, with an excess of tartaric acid, produces a white, crystalline precipitate" (U. S. Ph.). By the tests required in the Pharmacopœia, the standard quality of the salt is that of the "pure" carbonate, made out of the commercial impure article known as *pearlash*, by solution in water and subsequent granulation. Potassic carbonate is so deliquescent that unless carefully put up in well-stopped bottles it will eventually transform itself into an oily fluid, by dissolving in moisture attracted from the atmosphere.

Physiologically, potassic carbonate is simply a weakened potassa, yet not so weak but that, in strong solution, it may prove a corrosive poison. Its use is mainly in ointment or in aqueous solution as a strong alkaline potassic application in skin-diseases. Ointments of the carbonate are made with lard, the strength ranging from two to ten per cent. Solutions of the salt for service as lotions range in strength from one-half to one per cent.

Acid Potassic Carbonate: $KHCO_3$. The salt is officinal in the U. S. Pharmacopœia under the title *Potassii Bicarbonas*, Bicarbonate of Potassium. It occurs in "color-

less, transparent, monoclinic prisms, permanent in dry air, odorless, having a saline and slightly alkaline taste, and a feebly alkaline reaction. Soluble in 3.2 parts of water at 15° C. (59° F.), and decomposed by boiling water; almost insoluble in alcohol. At a red heat, the salt loses thirty one per cent. of its weight. The aqueous solution, on being heated, disengages carbonic-acid gas, and finally contains carbonate of potassium. It effervesces on the addition of acids, and, with tartaric acid in excess, it produces a white, crystalline precipitate" (U. S. Ph.). This salt should be kept in well-stopped bottles.

Physiologically, this carbonate is similar to the normal salt, but weaker. The taste is mild, though mawkish; the alkalinity feeble, and the salt is hardly capable of being corrosive. The uses are, locally, as an alkaline application in skin-disease, in preparations such as are described above in speaking of the normal carbonate, and, internally, as a stomachic or constitutional alkali. But for stomachic purposes sodic salts are more agreeable, and for constitutional alkalies the potassic citrates and tartrates. If given internally, the dose ranges from 1.00 to 4.00 Gm. (from fifteen grains to a drachm).

Normal Potassic Citrate: $K_3C_6H_5O_7.H_2O$. This salt, formerly known as *Salt of Riverius*, is officinal in the U. S. Pharmacopœia under the title *Potassii Citras*, Citrate of Potassium. It is a "white, granular powder, deliquescent on exposure to air, odorless, having a slightly cooling, faintly alkaline taste, and a neutral or faintly alkaline reaction. Soluble in 0.6 part of water, at 15° C. (59° F.), and very soluble in boiling water; very slightly soluble in alcohol. When heated to about 200° C. (392° F.) the salt loses nearly 5.5 per cent. of water. At a higher temperature it chars, and, if kept at a red heat, until gases cease to be evolved, it is converted into a blackened mass of an alkaline reaction, which strongly effervesces with acids. The aqueous solution of the salt yields a white, crystalline precipitate on the addition of a saturated solution of bitartrate of sodium. It remains clear on the addition of chloride of calcium until it is boiled, when a white, granular precipitate is produced" (U. S. Ph.). Potassic citrate is a not disagreeable-tasting, cooling salt, which is devoid of all local harsh effect, and yet after absorption seems to undergo decomposition as regards its acid radicle, becoming converted into a carbonate. Such secondarily formed carbonate thereupon exerts the usual action of an alkaline potassic compound, as detailed under Potassa above. Potassic citrate is thus available as a gentle diuretic, diaphoretic, and cardiac sedative in fevers, and also as an agreeable and yet efficient agent for constitutional alkalizing. It may be given freely in doses of from 1.00 to 2.00 Gm. (fifteen to thirty grains) in water or in effervescing water, sweetened or aromatized to taste. In order to obtain the salt in effervescing solution, in which condition it is more grateful to a fevered stomach, the following preparations are officinal in the U. S. Pharmacopœia: *Mistura Potassii Citratis*, Mixture of Citrate of Potassium, commonly called *Neutral Mixture*. This preparation is simply fresh lemon-juice, strained, and then neutralized with "bicarbonate" of potassium. About ten per cent. of the potassic salt is generally the quantity required for such neutralization. The mixture should be made fresh when wanted, but the best way of all is to prepare each dose extemporaneously at the bedside, so that it may be drunk during effervescence—constituting what is known as an *effervescent draught*. For this purpose a stock bottle of an aqueous solution of either normal or acid potassic carbonate should be ordered—six per cent. in strength if the former, eight per cent. if the latter, be selected. Then when a dose is wanted a tablespoonful of this solution is mixed with a tablespoonful of fresh lemon juice diluted with a tablespoonful of water, and the mixture is drunk during the effervescence which immediately ensues. Should fresh lemon-juice not be procurable, a six per cent. solution of citric acid is an efficient substitute, and if a drop or two of the volatile oil of lemon be triturated with the crystals of the acid before solution, the imitation of the natural lemon flavor is practically perfect. *Liquor Potassii Citratis*, Solution of Citrate of Potassium: This is a simple aqueous solution of the salt effected by bringing together in water six per cent. of citric acid and eight per cent. of acid potassic carbonate. It contains nine per cent. of potassic citrate, and should be made fresh when wanted. But the effervescing draught made as above at the bedside by the use of citric acid is a better way of getting the same solution.

Potassic Acetate: $KC_2H_3O_2$. The salt is officinal as *Potassii Acetas*, Acetate of Potassium. It occurs in "white, foliaceous, satiny, crystalline masses, or a white granular powder, very deliquescent, odorless, having a warming, mildly pungent and saline taste, and a neutral or faintly alkaline reaction. Soluble in 0.4 part of water and in 2.5 parts of alcohol at 15° C. (59° F.); very soluble in boiling water and in boiling alcohol. When strongly heated, the salt melts; at a higher temperature it evolves empyreumatic, inflammable vapors, and leaves a blackened residue of an alkaline reaction" (U. S. Ph.). On account of the extreme proneness of this salt to deliquesce it must be kept in well-stopped bottles, and the package opened as seldom as may be. Potassic acetate is generally similar in properties to the citrate, undergoing, like that salt, conversion into a carbonate after absorption, and so operating constitutionally as a potassic alkali. It is not so agreeable to the taste nor so grateful to the stomach as the citrate, but has a considerable reputation as a diuretic, as evidenced by its old cant name of *Sal diureticum*. As a matter of fact, however, it—often, at least—does not prove more diuretic than the citrate or other potassic salts. Potassic acetate may be used for the same purpose and in the same doses as the citrate.

Potassio-sodic Tartrate: $KNaC_4H_4O_6.4H_2O$. This well-known salt, commonly called Rochelle or Seignette's Salt, is officinal in the U. S. Pharmacopœia under the title *Potassii et Sodii Tartras*, Tartrate of Potassium and Sodium. It occurs in "colorless, transparent, rhombic crystals, slightly efflorescent in dry air, or a white powder, odorless, having a cooling, mildly saline and slightly bitter taste, and a neutral reaction. Soluble in 2.5 parts of water at 15° C. (59° F.), and very soluble in boiling water; almost insoluble in alcohol. When rapidly heated to about 75° C. (167° F.), the salt melts in its water of crystallization; at a higher temperature it dries, then chars, evolves inflammable vapors having the odor of burnt sugar, and, on moderate ignition, leaves a blackened residue of an alkaline reaction, strongly effervescing with acids, and imparting to a non-luminous flame an intense yellow color, which appears red when observed through a blue glass" (U. S. Ph.). This salt is decomposed by acids, with the production of a crystalline precipitate of acid potassic tartrate ("bitartrate"), and also by soluble plumbic, calcic, and basic salts.

Rochelle salt is mild in flavor and local action, agrees well with even a sensitive stomach, and differs from the citrate and acetate in being of low, rather than high diffusion-power. Hence in full dose it is purgative, but as compared with the average of saline purges ranks among the milder. In non-purgative dose, especially if given well diluted, it is absorbed, changes to carbonate after the manner of the citrate and acetate, and then exerts, as efficiently as other salts, the specific action of alkaline potassic compounds. From its mildness it is preferred by many to other potassium preparations as a constitutional alkali in rheumatism, lithæmia, etc. For constitutional action as an alkali or as a diuretic the salt is to be given in comparatively small but frequently repeated doses, not to exceed, as a rule, 4.00 Gm. (one drachm) at a time. As a purge, the dose will range, according to the intensity of the effect desired, from 8.00 Gm. to 30.00 Gm. (two drachms to an ounce) in water, plain or aromatized. A favorite mode of administration is in effervescent solution, as obtained by use of the officinal *Pulvis Effervescens Compositus*, Compound Effervescing Powder. This is the well-known *Seidlitz powder*, and consists of two parts, one a powder in blue paper, made up of about 2.60 Gm. (forty grains) of acid sodic carbonate ("bicarbonate") and about 8.00 Gm. (two drachms) of Rochelle salt and the other a smaller powder in white paper, consisting of about 2.25 Gm.

(thirty-five grains) of tartaric acid. Each portion is to be dissolved separately in about 60.00 Gm. (two fluid-ounces) of iced water, sweetened and aromatized if so desired, and the solution of the acid to be then added, half at a time, to that of the salts, and the potion drunk during the effervescence which immediately occurs. The reaction upon mixing the solutions is, of course, the decomposition of the sodic carbonate by the tartaric acid, with the formation of a sodic tartrate and the evolution of carbon-dioxide gas. A single "powder" is a medium purgative dose.

Normal Potassic Tartrate: $(K_2C_4H_4O_6)_2$. H_2O.—The salt is officinal in the U. S. Pharmacopœia as *Potassic Tartras*, Tartrate of Potassium. It is sometimes called *soluble tartar*, in contradistinction to the acid tartrate, which is comparatively insoluble. Potassic tartrate occurs in "small, transparent or white, monoclinic crystals, or a white powder somewhat deliquescent, odorless, having a saline, slightly bitter taste and a neutral reaction. Soluble in 0.7 part of water at 15° C. (59° F.), and in 0.5 part of boiling water; almost insoluble in alcohol. When heated, the salt melts, then chars, and evolves inflammable vapors having the odor of burnt sugar. On moderate ignition it leaves a blackened residue of an alkaline reaction, strongly effervescing with acids. A concentrated, aqueous solution of the salt yields a white, crystalline precipitate on the addition of acetic acid. With test-solution of nitrate of silver it yields a white precipitate, which becomes black on boiling" (U. S. Ph.). This tartrate acts similarly to Rochelle salt, and may be used for similar purposes in similar doses, but is comparatively seldom employed because of its disagreeable, bitterish taste.

Acid Potassic Tartrate: $KHC_4H_4O_6$.—This well-known salt, the *cremor tartari* or *cream of tartar* of common parlance, is officinal in the U. S. Parmacopœia under the title *Potassii Bitartras*, Bitartrate of Potassium. It is prepared by a process of purification from the impure salt occurring as an incrustation developing in casks of wine, especially of acid wines. Such incrustation is called *argol*, or *crude tartar*, the latter name being derived from the *tart* quality of the wines that furnish the greatest yield of the substance. The purified salt may be in crystals, but as furnished to pharmacists it is in fine powder, to which condition especially the cant name of "cream of tartar" applies. The characteristics are: "Colorless or slightly opaque, rhombic crystals, or a white, somewhat gritty powder, permanent in the air, odorless, having a pleasant, acidulous taste and an acid reaction. Soluble in 210 parts of water at 15° C. (59° F.), and in 15 parts of boiling water; very slightly soluble in alcohol. When heated, the salt chars and evolves inflammable vapors having the odor of burnt sugar. On moderate ignition it leaves a blackened residue of an alkaline reaction, which strongly effervesces with acids. The salt is dissolved by warm solution of potassa, and is again precipitated on the addition of hydrochloric acid. Its aqueous solution, rendered neutral by potassa, produces, with test-solution of nitrate of silver, a white precipitate, becoming black by boiling" (U. S. Ph.). Among the above-described properties, the sparing solubility in cold water should be noted. This solubility can be brought to the proportion of one to one by the addition of borax, and in the German Pharmacopœia there is a preparation called *Tartarus boraxatus*, "potassic boro-tartrate," made by dissolving two parts of borax in twenty of water, adding five parts of cream of tartar, dissolving by stirring over a steam-bath, filtering, evaporating to dryness, and pulverizing. The product is a very deliquescent white powder, soluble in its own weight of water. Commercial cream of tartar always contains more or less calcic tartrate, which salt is a normal constituent of crude tartar, but, according to the pharmacopœial standard, the proportion should not rise above six per cent. Besides this natural impurity, adulterations are often found, such as chalk, gypsum, clay, sand, or flour. Purchase of the article in crystals affords the surest way to avoid these sophistications.

Cream of tartar is a cooling, acidulous salt, agreeing well with delicate stomachs. Like Rochelle salt, it is of low diffusion-power and therefore cathartic, and in its purgative action is characterized by the copiousness of the watery dejections it determines. For this reason it is a favorite ingredient of cathartic mixtures intended for carrying off a dropsical effusion, such as the compound powder of jalap of the U. S. Pharmacopœia. In non-purgative dosage the salt is refrigerant and diuretic—perhaps more generally diuretic than any other potassic compound, but, unlike the other potassic salts of organic acids, it does *not* appear to suffer the usual conversion in the blood into a carbonate. Such, at least, is the inference from the clinical observation that cream of tartar is not of the same value for constitutional alkalizing as are, respectively, the other tartrates, the citrate, and the acetate. The uses of the present salt are therefore restricted to its application as a purge, a diuretic, or a grateful, cooling saline in feverishness. The doses are substantially the same as those of Rochelle salt for the same several purposes. The powdered cream of tartar may be suspended in water or mixed with molasses for giving as a purgative, or, for use as a fever-draught, may be dissolved in boiling water, and the solution, when cold, given sweetened with sugar. The old-fashioned, so-called *imperial* draught is made by dissolving one per cent. of cream of tartar in boiling water, adding one per cent. of sliced lemon and eight of white sugar. *Cream of tartar whey*, so called, consists of one and a half per cent. of the salt in milk.

Normal Potassic Sulphate: K_2SO_4. The salt is officinal in the U. S. Pharmacopœia under the title *Potassii Sulphas*, Sulphate of Potassium. It occurs in "colorless, hard, six-sided, rhombic prisms, permanent in the air, odorless, having a sharp, saline, slightly bitter taste and a neutral reaction. Soluble in 9 parts of water at 15° C. (59° F.), and in 4 parts of boiling water; insoluble in alcohol. When heated, the crystals decrepitate, and at a white heat they fuse, solidifying or cooling to a crystalline mass of an alkaline reaction. The aqueous solution yields a white, crystalline precipitate on the addition of a saturated solution of bitartrate of sodium. With test-solution of chloride of barium it yields a white precipitate, insoluble in nitric acid" (U. S. Ph.). Potassic sulphate is, like all sulphates, comparatively harsh, and in large concentrated dose has caused fatal irritant poisoning. It is of low diffusion-power, therefore purgative, and its medical use has been as a saline cathartic. It is, however, little used, because of its occasional harshness. The dose will range from 8.00 to 16.00 Gm. (two to four drachms), to be given in solution, well diluted. This is the salt formerly called *vitriolated tartar* and *sal de duobus*.

Potassic Nitrate: KNO_3. This salt, the well known substance *nitre*, or *saltpetre*, is officinal in the U. S. Pharmacopœia under the title *Potassii Nitras*, Nitrate of Potassium. It occurs as "colorless, transparent, six-sided, rhombic prisms, or a crystalline powder, permanent in the air, odorless, having a cooling, saline, and pungent taste and a neutral reaction. Soluble in 4 parts of water at 15° C. (59° F.), and in 0.4 part of boiling water; almost insoluble in alcohol. When heated to about 340° C. (644° F.), the salt melts; at a higher temperature it is decomposed, giving off oxygen, and leaving a residue which emits nitrous vapors on the addition of sulphuric acid. Thrown upon red-hot coals the salt deflagrates. The aqueous solution of the salt yields a white, crystalline precipitate on the addition of a saturated solution of bitartrate of sodium" (U. S. Ph.). Under the name of *sal prunelle* or *crystal mineral*, nitre is also to be found in the shops in small circular cakes, moulded from the salt, fused. Commercial refined saltpetre is the quality of the salt to be employed in medicine, and an article in small crystals is preferable to one in large, since large crystals are apt to contain some water, mechanically entangled in the process of crystallization.

Potassic nitrate, like the sulphate, is a powerful salt in local operation, but, unlike the sulphate, is of high diffusion-power, so that even a large dose will be compara-

tively quickly absorbed. Taken internally it is therefore doubly potent, and even poisonous, a large dose exciting severe irritant poisoning, and consecutively producing in the highest degree the dangerous constitutional effects of the potassic compounds generally. The salt undergoes no decomposition in the system, and is therefore incapable of exerting any *alkaline* effects, either local or constitutional. In medicinal doses nitre produces the antifebrile effects of the potassium salts generally, being cooling and grateful to the stomach, and tending, after absorption, to quiet a bounding heart and at the same time to prove gently diuretic and diaphoretic. Being of high diffusion-power, it does not purge except in considerable dose. A peculiar property of nitre is that, mixed with fresh venous blood, it turns the blood bright red and impairs its coagulability; but in spite of much theorizing, the fact does not lead to any special therapeusis. Medicinally nitre is nowadays probably rarely used internally, except as an ingredient of fever-draughts or of diuretic mixtures. Formerly it had considerable reputation in the treatment of acute rheumatism, being pushed in full doses, but alkalies and salicylates have now supplanted the salt for this application. The single dose of nitre should not exceed 2.00 Gm. (thirty grains), and the salt is best given in dilute solution. Considerable single amounts, especially if in concentrated condition, are dangerous, but so rapid are the absorption and elimination of the nitrate that, by means of small and frequent doses, properly diluted for the taking, a very large quantity—from 30.00 to 62.00 Gm. (one or two ounces)—can be passed through the system in the course of a single day without injury. A special therapeutic application of saltpetre is the inhalation, for the relief of spasmodic asthma, of the fumes arising from its combustion. As usual in antispasmodic medication, some cases find relief from the agent and others do not, or even suffer aggravation thereby. For the application white unsized paper, free from wool, is steeped in a twenty-five per cent. aqueous solution of nitre and allowed to dry. A piece is then burned, and the patient, with the face as near as can be borne without undue irritation, inhales the white fumes that are given off. Such prepared paper is officinal in the U. S. Pharmacopœia under the title *Charta Potassii Nitratis*, Nitrate of Potassium Paper. It is sometimes called *asthma paper*. Toxicologically nitre is of some importance, cases of poisoning by the salt not infrequently occurring. An ounce, swallowed at a draught, has proved fatal in a number of instances. Taken, as it commonly is in such cases, in pretty strong solution in mistake for purgative salts, the symptoms are mainly those of severe gastro-intestinal irritation—burning pain in the stomach, violent vomiting and purging, the dejecta being sometimes bloody, and general collapse. Whether the constitutional symptoms are merely symptomatic of shock from the irritation, as occurs so commonly with powerful irritant poisons like the mineral acids, or whether they are in part the expression of the specific potassium-poisoning of nerve and muscle, is not always easy to determine, and is of no practical bearing on the treatment of the poisoning. Special symptoms are urinary suppression, with strangury, tenesmus, and bloody urine, and aphonia. These may or may not occur. Death may take place in two hours after the swallowing of the poison. There is no chemical antidote to nitre, so that the treatment of a case of poisoning must be conducted simply on general medical principles.

Potassic Chlorate: $KClO_3$. The salt is officinal in the U. S. Pharmacopœia under the title *Potassii Chloras*, Chlorate of Potassium. It occurs in "colorless, monoclinic prisms or plates, of a pearly lustre, permanent in the air, odorless, having a cooling, saline taste, and a neutral reaction. Soluble in 16.5 parts of water, at 15° C. (59° F.), and in 2 parts of boiling water; only slightly soluble in alcohol. When heated, the salt melts and afterward gives off an abundance of oxygen, finally leaving a residue of a neutral reaction, amounting to 60.8 per cent. of the original weight, and completely soluble in water" (U. S. Ph.). The Pharmacopœia also heads its description with the important injunction that this salt "should be kept in well stopped bottles, and should not be triturated with readily oxidizable or combustible substances." Violation of the latter precept may be followed by an explosion.

The chemical relationship between chlorates and nitrates is paralleled, as usual in such cases, by resemblance in physiological action. The present salt thus closely resembles nitre in its effects, the principal difference being in intensity of power, the chlorate being the weaker—a fact probably in part due to the less ready solubility of the salt. Yet the chlorate is strong enough, in full concentrated dose, to be fatally poisonous, with symptoms of intense gastro-intestinal irritation, and, in too lavish medicinal use, as has been the fashion in diphtheria, to be the likely cause of much of the nephritic disorder thoughtlessly assigned, in etiology, to the disease instead of to the medicine.[3] For, like the nitrate, the chlorate of potassium has a distinct tendency to irritate the kidneys, which, in the choked condition of the organs common in diphtheria, may easily lead to dangerous congestion. Potassic chlorate was forced into medicinal notoriety largely by the theoretical consideration that, since chlorates readily part with some of their oxygen, thus proving active oxidizing agents, the salt ought to serve as a constitutional source of oxygen within the animal system, and so prove of benefit in diseases that tax the nutritive powers of the organism. Clinical experience, however, does not bear out the prognostications of theory, and physiological chemistry accounts for the failure by finding that, under the conditions of the animal circulation, potassic chlorate suffers no decomposition, but is eliminated by the kidneys and other organs unchanged. The only rational place of this salt in medicine hinges on the following fact: The chlorate is largely eliminated by the salivary glands, and probably also by the mucous follicles of the mouth and pharynx, and in inflammatory conditions of the surface-textures of these parts distinctly tends to healing. Sore mouth or sore throat, catarrhal or ulcerative, is therefore often with advantage treated with potassic chlorate in the form of wash or gargle, or, better still, for the sake of continuous application to the parts through the avenue of the saliva and buccal mucus, given internally. A convenient practice is to prescribe a five per cent. aqueous solution of the salt, which is upon the verge of a saturated solution, and direct this to be used as a mouth-wash or gargle every two hours, and at the same time a couple of teaspoonfuls to be taken internally. Such quantity will represent about 0.50 Gm. (eight grains) of the salt—a moderate single internal dose. Among the varieties of buccal disorders amenable to potassic chlorate may be mentioned mercurial stomatitis; and some practitioners even combine the potassic salt with their mercurials in constitutional mercurialization, with the view of lessening the risk of salivation. In diphtheria, also, the chlorate is a good deal used, the good effects being probably the local ones only, and the risk to kidneys or heart from too free dosage being genuine and considerable. Of preparations, the U. S. Pharmacopœia makes officinal *Trochisci Potassii Chloratis*, Troches of Chlorate of Potassium, the ingredients being the salt, sugar, and tragacanth, and a little of spirit of lemon for flavoring. Each troche contains 0.32 Gm. (five grains) of chlorate. In ordinary sore throats or sore mouths, for the treatment of which affections the preparation is especially intended, these lozenges, if allowed to dissolve naturally without chewing, may be taken continuously through the day. *Edward Curtis.*

[1] Ringer and Murrell: Journal of Physiology, i., p. 88.
[2] Basham: Practitioner, vol. v., p. 259.
[3] Jacobi: Medical Record, vol. xv., p. 241.

POTT'S DISEASE. Synonyms.—Caries of the Spine, Spondylitis, Malum Pottii, Pott's Kyphosis, Mal vertébral, Angular Curvature, Spondylarthrocace.

Definition.—A disease of the spinal column, characterized by a caries of the vertebral bodies with the attendant changes.

The disorder was first accurately described by Percival

Pott in 1779,[1] but the characteristic deformity had been mentioned by the older writers, and the disease itself is probably as old as humanity; the specimen in the Peabody Museum (Fig. 3050) shows that the disease was not unknown among the prehistoric tribes of the North American Indians in Tennessee. It also demonstrates the possibility of spontaneous recovery, even when the disease has involved many vertebræ.

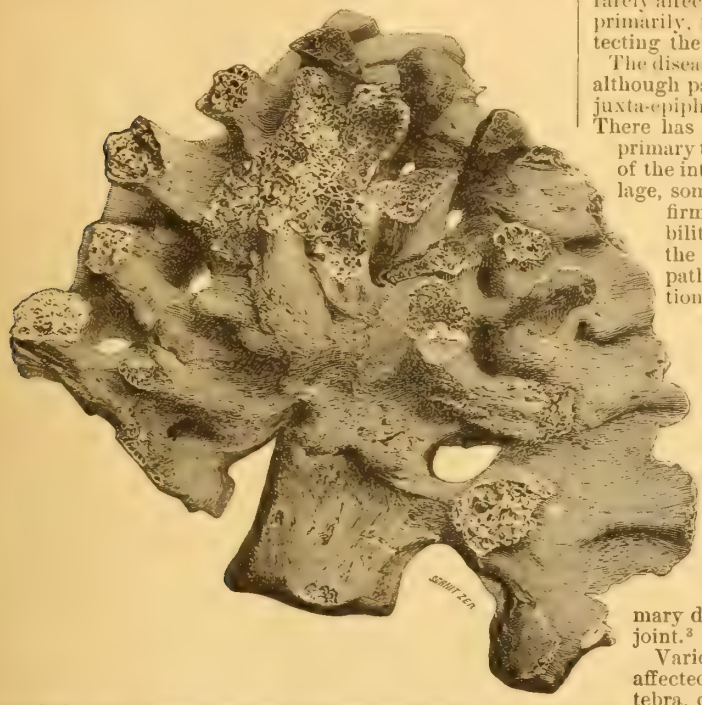

Fig. 3050.—Pott's Disease Involving the Whole Dorsal Region. Prehistoric Indian Remains. (Peabody Museum, Spec. 17223.)

Pathological Anatomy. — Pathologically, the affection is an osteitis of the spongy portion of the vertebræ, and the morbid process is the same as that observed in all spongy bone, viz., a destructive osteitis, localized or diffused. This process may be followed or attended by an ossifying osteitis, which limits the extent of the destructive process, and in favorable cases effects a cure by anchylosis. A description of the pathological histology of caries does not come within the scope of this article. It may, however, be mentioned here that the tuberculous nature, affirmed by Nélaton, of spinal caries is at present accepted as probable by pathologists.[2]

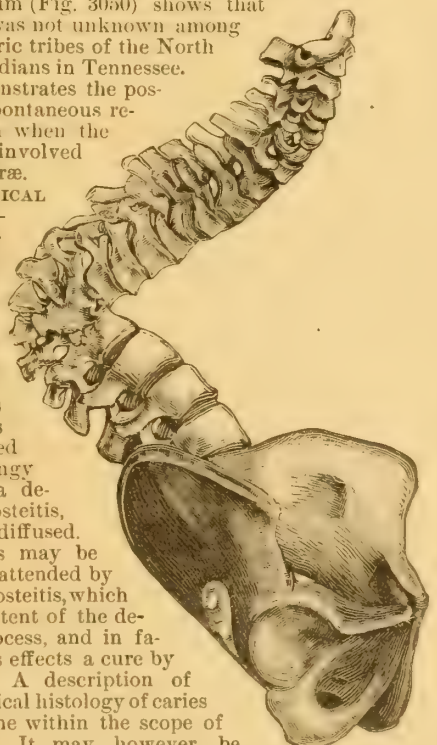

Fig. 3051.—Spinal Column in Well-marked Caries of Spine. (Warren Museum.)

The carious process is limited, as a rule, to the vertebral bodies; the transverse, articular, or spinous processes are rarely affected secondarily, and, as far as is known, never primarily, their structure of hard bone apparently protecting them from tubercular invasion.

The disease is therefore in no sense an articular affection, although pathologically it resembles the epiphyseal and juxta-epiphyseal osteites classed among the joint diseases. There has been much discussion as to the possibility of primary tubercular disease of the intervertebral cartilage, some authorities affirming its impossibility, and denying the reliability of the pathological observations cited as proof to the contrary. The facts are that the intervertebral cartilage is absorbed at an early stage in the disease, but that a few cases have been reported by reliable observers where there would appear to be no doubt that the cartilage alone was affected, as has been observed in a few rare instances of primary disease of the semilunar cartilages of the knee-joint.[3]

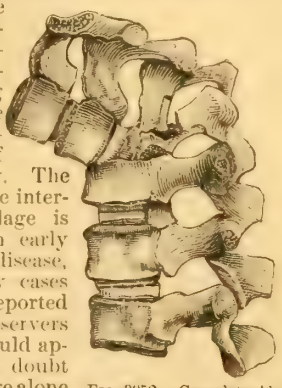

Fig. 3052.—Complete Absorption of Vertebral Body. (Warren Museum.)

Various portions of the vertebral bodies may be affected; there may be two or more foci in one vertebra, or the whole body may be equally affected; the disease may be limited to one spot, forming a localized abscess of the bone, or it may extend so as to involve the adjacent vertebræ. Primary disease of two vertebral bodies in different, non-adjacent parts of the spine is rare, but has been recorded. But an extensive destruction of many adjacent vertebræ from primary disease of one may be said to be the rule in Pott's disease. In some instances this destructive process may be limited to the surfaces of a large number of vertebral bodies; in others a few contiguous vertebral bodies are completely destroyed. The number of vertebræ involved necessarily varies; in some instances the bodies of twelve or even more have been destroyed, producing a deformity involving almost the whole of the spinal column. A superficial caries of the anterior surfaces of the bodies, without involving the intervertebral cartilages or impairing the weight-bearing function of the vertebræ, has been observed, though it is rare.

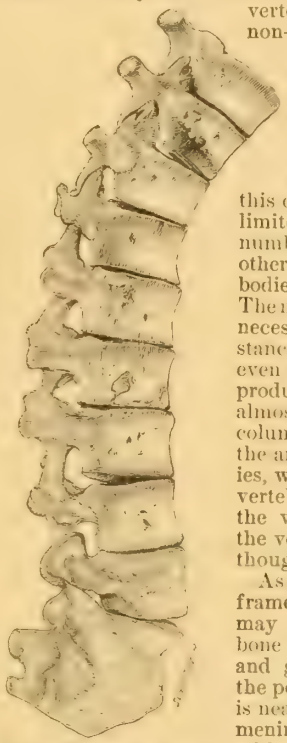

Fig. 3053.—Primary Disease of Two Different Parts of Spinal Column.

As elsewhere in the human frame, the destructive process may spread from the carious bone to the adjacent soft tissues and give rise to an abscess; if the portion of the bone involved is near the spinal canal, a pachymeningitis frequently follows, with a resulting lesion of the cord if the process continues long enough.[4]

The causation of Pott's disease is not definitely determined as yet. That the disease is of a tuberculous nat-

are is frequently asserted and seems probable, and as often, some fall or injury is regarded as an exciting cause.

Gibney,[5] in an examination of 185 cases, found a hereditary tuberculous taint in 76 per cent. This was in 35 per cent. inherited from the father; from the mother in 38 per cent.; in 31 per cent. from both. In 15 per cent. it existed in other children of the family, and in 16 per cent. the taint was manifest in both parents and children. In 45 per cent. a weakened condition from previous sickness was found; and in 22 per cent. both an inherited and an acquired diathesis was found. Taylor,[6] in 845 cases, found 53 per cent. to be with a history of preceding trauma; in 15 per cent. there was disease of lung in nearer or more distant relatives; in 19 per cent. so-called scrofula was claimed, and a sickly diathesis in 34 per cent.

Sex does not appear to be an important factor in causation, though statistics vary somewhat. Gibney (*loc. cit.*) found, in 2,455 cases of Pott's disease, 1,329 males, 1,126 females. Mohr found females slightly more numerous than males. Fisher,[7] in 500 cases, found 261 males, 239 females. Taylor,[8] in 412 cases, found 234 boys, 177 girls.

The disease is more common in childhood. Mohr[9] found, in 72 cases, that the disease occurred between the first and fifth years in 29 per cent.; between the sixth and tenth years in 22 per cent.; eleventh and fifteenth years, 22 per cent.; sixteenth and twentieth years, 16 per cent.; and above the twentieth year, in 11 per cent. Drachman found, in 161 cases, 41 per cent. between one and five years; 36 per cent. between five and ten years; 13 per cent. between ten and fifteen years; 5 per cent. between fifteen and twenty years; 4 per cent. between twenty and twenty-five years. The oldest case was seventy-seven years of age, and the youngest eight weeks. Gibney (*loc. cit.*) found 87 per cent. were under fourteen years of age; 7 per cent. between fourteen and twelve; 4 per cent. over twenty-one. Taylor[10] found, in 375 cases, 226 were under five; 68 between five and ten; 24 between ten and fifteen (N. Y. *Med. Record*, August 13, 1881).

Jaffé found, in post-mortem examination of 317 cases of tuberculosis of bones and joints, that there was caries

Fig. 3054.—Frequent Position of Head in Cervical Caries.

of the spine in 26 per cent. of the cases; in bones of the feet in 21 per cent.; in the hip-joint in 13 per cent.; in the knee-joint, 10 per cent.; in the hand, 9 per cent.; and in the elbow, 4 per cent.

The erect position of the body is a factor of importance in causing disease of the spine, or, in other words, that position which necessitates superincumbent pressure upon an injured vertebral body. Caries of the spine is said not to be found in quadrupeds.[11]

Localization.—The mobility of the spine—that is, its forward bending—appears to influence, to an extent, the localization of the disease, although this is a matter not fully determined. Any of the vertebræ may be attacked, but in varying frequency. Statistics are of uncertain value, as they are chiefly based upon autopsies and, therefore, from adults. Mohr (*loc. cit.*), in 56 autopsies of caries of the spine, found that the disease is most common in the thoracic region (33 in 56 cases), next in the lumbar region (27 times) and next in the neck (12 times). The sacrum was diseased in one case. As there are more dorsal vertebræ than either cervical or lumbar, it is natural that the number of cases of dorsal disease should be greater than in the other regions. In adults Mohr found the first lumbar to be the one most frequently diseased, the second lumbar the next, the fourth dorsal, twelfth dorsal, and the fifth lumbar attacked nearly as frequently. Billroth and Menzel found, in autopsies, the first and second cervical vertebræ the ones most frequently attacked, and next to these the sixth, fourth, and eighth dorsal, the fourth and eighth lumbar, the tenth and ninth dorsal, and the third cervical, in the above order. The vertebræ least frequently attacked were, according to Mohr, the ninth, tenth, and eleventh dorsal, the fourth lumbar, and the fifth and sixth cervical. Billroth and Menzel found the fifth and sixth cervical, the first and second dorsal, and the first lumbar, the vertebræ least often attacked. Jaffé found, in the examination of living subjects, that the sixth and seventh dorsal were the vertebræ most frequently attacked; and he found, also, that the lumbar vertebræ were less frequently, and the cervical more frequently, the seat of disease than had been supposed from post-mortem examination.

Fig. 3055. Position of Head in Cervical Caries.

Taylor found, in an examination of 300 living patients with caries of the spine, that the points of greatest liability to the disease to be, first, the sixth and seventh cervical; second, near the eighth dorsal; third, the second and third lumbar. The points of least liability to the disease are from the first to the fourth dorsal and the eleventh and twelfth dorsal, besides the two extremities of the spinal column.[12] Although, as is seen, the locations of relative frequency given by the different observers do not agree, it would appear that certain portions of the spine are more liable to attack than certain others, and that the theory advanced by Taylor was a plausible one—viz., that the regions most liable to the disease were those which were the most exposed to jars or increased pressure; that the disease would be more frequent where the hinges of motion at the spinal column came, varying to a degree according to age and occupation, or where there was the greatest exposure to the effects of violent jars.

Fig. 3056.—Elevation of Chin in Caries of the Upper Dorsal Spine.

In short, it may be assumed that the determining cause of caries of spine is jar or superincumbent pressure; the influential cause, that physical state which is incapable of resisting slight trauma, exposing the tissue probably to the invasion of the tubercle-bacillus.

Symptoms.—The clinical history varies necessarily in different cases, and also as to the part of the spine affected. The earliest symptoms are not easily recognized, and are frequently overlooked until the deformity leaves no doubt of the existence of the disease.

Peculiarity of attitude, muscular stiffness, and referred pain are the most prominent of the earlier symptoms, and they may be present before a projection has been noticed. The importance of these early symptoms can hardly be overstated, as it is on an early recognition of the affection that the hope of a ready cure is to be based.

Attitude.—The peculiarity in attitude noticed early in the disease is due either to reflex muscular spasm—similar to that seen in joint-disease (notably that of the hip-joint), or to an unconscious effort on the part of the patient to prevent jar or any increased pressure upon the affected vertebral bodies. These attitudes necessarily vary according to the point of the spine attacked. In disease of the upper cervical region the most common attitude is that of wry-neck. This is sometimes confounded with idiopathic torticollis, and patients in some instances have been subjected to tenotomy under a mistaken diagnosis.

When the disease is in the lower cervical region and upper dorsal, the chin is held somewhat raised, to balance the weight of the head on the articular facets, suggesting the position of a seal's head when out of water. The spinal column below the point of disease is abnormally straight, and in some instances curved slightly forward; while in the lower dorsal region an exaggerated projection of the spinous processes backward may be seen, due to a compensating curve; this projection is sometimes so marked as to suggest that the disease has attacked another part of the spine.

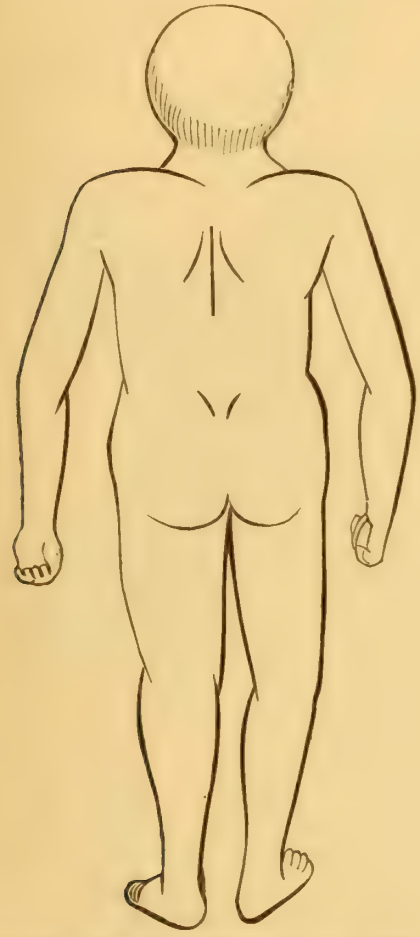

Fig. 3057.—Elevated Shoulders in Upper Dorsal Disease.

In the middle dorsal region, the attitude to be noticed most frequently is an elevation of the shoulders. Sometimes one shoulder is held for a time higher than the other, and temporarily a slight lateral deviation of the spine is to be seen.[13]

In the lumbar region, the patient in the early stage frequently will be noticed to lean backward, like pregnant women or adults with large abdomens.

A peculiar position and characteristic sidling gait is sometimes seen, at a comparatively early stage of disease in the lower dorsal or lumbar region, due to a slight contraction of the psoas and iliacus muscles.

In a late stage, when psoas abscess is present, a marked contraction of these muscles takes place; but even when there is no evidence of existence of suppuration or of a psoas abscess, slight inflammatory irritation of the muscles will produce a limitation to the arc of extension of the thigh on the trunk. This may be so slight as to be noticed only by placing the patient on the face and attempting extreme extension of the thigh. If more muscular resistance is met on one side than on the other, or than is usually encountered, it may be assumed that the increased tonicity is the result of irritation of some of the muscular fibres extending the thigh.

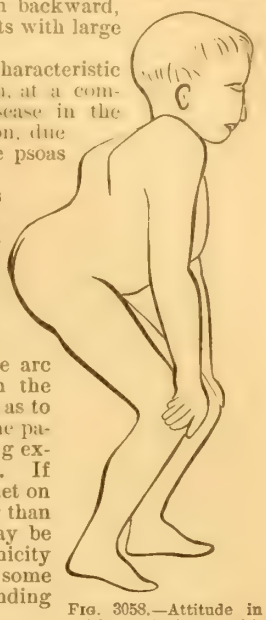

Fig. 3058.—Attitude in Advanced Disease with Psoas Contraction.

In addition to the square position of the shoulders, the peculiar position of the head, the erect attitude of the upper part of the spine preventing the superincumbent weight of the trunk and upper extremities (above the diseased portion of the spine) from falling forward upon the diseased vertebral body, the gait is peculiar; the patient walks more on the toes than on the heels, and with the knees slightly bent—in such a way that all possible springs may be brought into play to diminish jarring the spine.

These peculiarities of attitude and position vary in severity according to the severity of the disease; they may be at one time more noticeable than at another. Characteristic also at this stage of the disease is a muscular stiffness more marked after the patient has been quiet for a while (during sleep). The stiffness of the limbs diminishes or disappears after the patient has moved about. A certain amount of muscular rigidity of the muscles of the back will be felt on palpation and in affections of the middle dorsal and lumbar regions; stooping involving arching of the back forward is difficult or impossible, and in attempting to stoop in order to pick up any article from the floor the patient will keep the spine erect and reach the floor lowering himself with an erect trunk, by bending the knees (Fig. 3060).

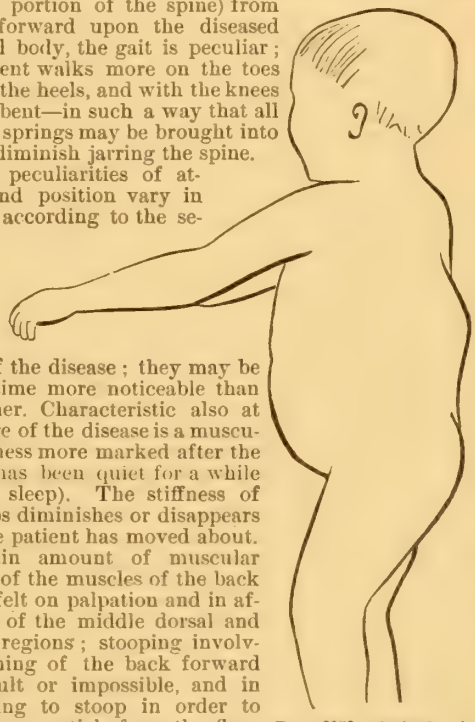

Fig. 3059.—Attitude in Pronounced Dorsal Caries.

Children will often be noticed to become tired more easily than usual, and after playing about for a time will

desire to lie down, to rest their arms upon a chair or seat, or to support the head with their hands, or the trunk by holding on to the thighs, according to the part of the spine affected.

The amount of muscular stiffness, rigidity, and difficulty in maintaining the spine erect is in a measure an index of the degree of activity of the disease. In early cases the muscles on either side of the area of the affected vertebræ will often, on bending the back, be seen to spring out in relief, acting like physiological splints to the diseased vertebral column.

Localization of Pain.—The localization of the referred pain in caries of the spine varies with the nerves affected.[36] The pain is referred to the ends of the nerves, and may be felt in the cervical, sternal, or abdominal regions, or in the limbs.

The pain is usually subacute, and may be only occasional. At times the attack may be very severe, accompanied by intense hyperæsthesia, so that the pressure of the bedclothes cannot be tolerated, and patients in this condition have been supposed to have intense peritonitis or pleurisy. The subacute form is more common, and this, together with muscular stiffness, often gives rise to a diagnosis of rheumatism, sciatica, or neuralgia. The pain in these cases is due to a compression of the nerves by inflammatory products as they pass out of the spinal canal. Analogous to these attacks of pain are disturbances of the functions of other nerves—manifested in cough, dyspnœa with cyanosis, gastric disorders, obstinate and recurring vomiting, and troubles of the bladder, with or without pain at the end of the penis. Patients suffering in this way have been treated for bronchitis, pneumonia, gastritis, or cystitis; and in one notable instance the operation for stone in the bladder, lateral cystotomy,[14] was performed and no vesical trouble discovered, but at the autopsy caries of the lumbar vertebræ was found.

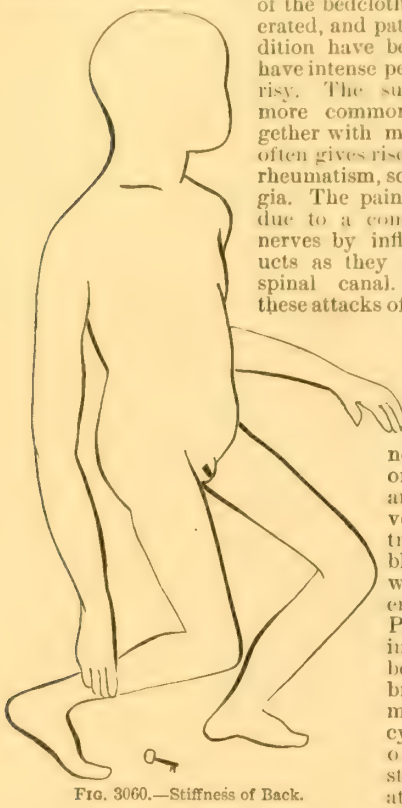

FIG. 3060.—Stiffness of Back.

These periods of suffering may become intense, constituting acute attacks, subsiding after rest, and recurring at intervals without apparent exciting cause.

Dilatation or contraction of the pupil, existing for some time, has been noted in cervical caries of the spine, with compression of the cord (Charcot).

Paralysis.—Motor disturbances are at first shown by exaggeration of the reflexes, which may or may not precede a complete paralysis.

Considering the fact that the spinal canal, containing the spinal cord, is so near the seat of disease in caries of the spine, it is not strange that paralysis is so common a symptom in Pott's disease. This complication is more frequent the higher the portion of the spinal column which is affected, for the reason that the cord is larger and the vertebral bodies smaller the higher we ascend in the column.

The disturbance of the function of the muscular system is very characteristic, and is not due, as was originally supposed, to pressure upon the cord from displaced bone, but to a transverse myelitis, subacute or chronic,[5] or, more properly, to a pachymeningitis or meningo-myelitis, with pressure upon the cord from the resulting granulation tissue,[16] as well as to secondary alterations in the substance of the cord itself in the lateral columns below the point affected, and in the posterior columns above the point. Microscopically, interstitial proliferation of the connective tissue, and degeneration of the nerve fibres are sometimes found; the changes can be observed with the naked eye, in a translucent, grayish or slightly yellowish color of the tissues, in fresh specimens of the cord. Usually, however, hardening in chromic acid is necessary before they can be seen.

Paralysis, however, may exceptionally be occasioned by the pressure of a projecting fragment of necrosed bone, or by the mechanical pressure of an abscess.[17]

The symptoms developed are those characteristic of myelitis by compression—paralysis is usually gradually developed,[18] paraplegia rather than hemiplegia, the paralyzed muscles may be relaxed and softened at first, but as the disease progresses the muscles become tense and rigid, with twitchings, both tonic and clonic, and exaggeration of the deep reflexes. Permanent contractures may be developed, contraction in an extended position of the limb coming before that in a flexed position; the reflexes, cutaneous and tendinous, are exaggerated. Sensation is, it is said, always impaired, but usually so slightly as to be determined only on careful examination; or there may be regions of anæsthesia, hyperæsthesia, or paræsthesia. As a rule, however, the motor paralysis is the chief feature, and sensation does not become gravely altered until very late, unless the centre of the cord is attacked. It has been stated (Courjon) that sensation is never entirely lost in caries of the spine. Paralysis of the rectum and bladder is rarely prominent and often wanting; bed-sores and cystitis occur only in the severer cases. Trophic disturbances and loss of electrical contractility are not to be seen unless in exceptional cases, where other parts of the cord than those usually affected have become secondarily changed.

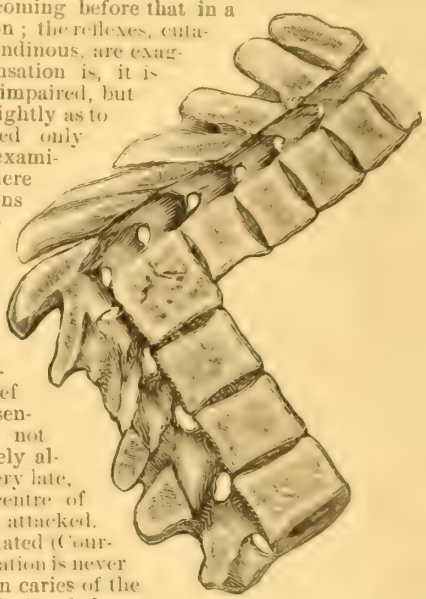

FIG. 3061.—Patency of Spinal Canal in Pronounced Caries of Spine. (Warren Museum.)

The wasting of the muscles and diminution of electric contractility are usually only such as disuse would cause; if, however, the lumbar or cervical enlargement is attacked, emaciation of the muscles and the loss of faradic contractility, with the reaction of degeneration, are to be noted.[19]

In a few instances affections of the joints, supposed to be secondary to lesions of the cord, have been noted, and an instance is mentioned in which herpes zoster, apparently due to the same cause, was present.

In myelitis of the cervical region, and in rare cases of dorsal disease, paralysis may affect the upper extremity as well as the lower, and that of the upper extremity may precede the lower.

Paralysis is rarely an early symptom in caries of the spine, though it has been observed before the stage of deformity; it is sometimes partial; it is usually pre-

ceded by paresis; it may rarely precede deformity. The frequency of paralysis is indicated by the figures collected by Gibney.[20] Out of 295 patients with caries of the spine, paralysis was noted 62 times; in 189 cases of caries of the upper dorsal and cervical region, paralysis occurred in 59; in 106 cases of lower dorsal and lumbar disease, paralysis occurred in only 3.

Paralysis is usually bilateral; it may, however, be unilateral, and in some unusual instances it occurs above the point of deformity. Taylor and Lovett[21] found in an examination of 59 cases (out of 445 cases of Pott's disease) that the location of disease was as follows: 1 cervical, 7 cervico-dorsal, 37 dorsal, 7 dorso-lumbar, 4 lumbar (3 unclassified). The deformity was large in 20, medium in 10, small in 17 (in 12 unclassified). The paralyzed cases presented no worse deformity than that seen in average cases. In 26 the outline of the deformity was rounded and gradual; in 16 it was markedly sharp. The paralysis occurred on the average about two years after the beginning of the disease. It came on immediately after a fall in 4 cases; in 8 cases it appeared within one year, in 26 within four years, and in 1 within five, in 29 within eleven, and in 10 within twenty-eight years. The duration of the paralysis was never, in the cases reported, over three years, except in 1 case, where it persisted with but little improvement for six years; in 2 cases it lasted three years; in 5 cases it lasted two years. A recurrence of the paralysis was noted in 6 cases, 4 having two attacks and 2 having three.

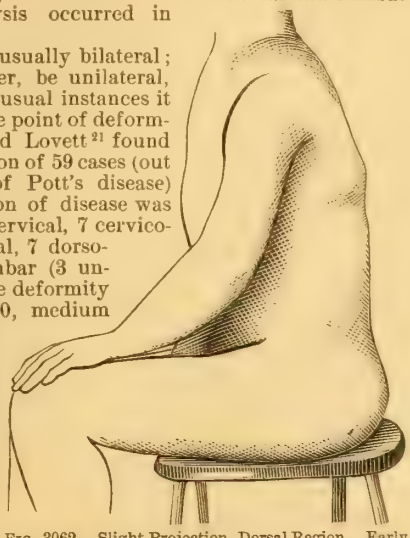

Fig. 3062.—Slight Projection, Dorsal Region. Early Caries of Spine.

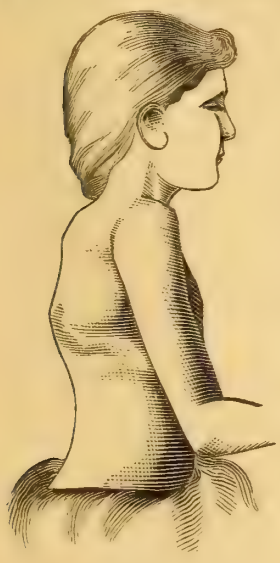

Fig. 3063.—Projection of Dorsal Region in Caries of the Spine. More advanced than that shown in Fig. 3062.

Out of 72 cases of caries of the spine watched by Mohr (*loc. cit.*), there was paralysis in seven per cent.; and of 61 cases of autopsy in death from caries of the spine, in eleven per cent. alteration and disease of the cord was found.

Paralysis in Pott's disease shows a remarkable tendency to recover, as has been already stated—a fact that many authorities have overlooked, taking their statistics from incurable hospital cases.

Recovery may take place after complete motor paraplegia with marked sensory impairment. In a few cases the paralysis recurs. Treves[22] quotes a case of recovery after complete paralysis of the lower limbs, with loss of power of the upper extremities and in the bladder. He mentions a case of two attacks of paralysis, occurring in the same patient in two years, followed by recovery; and another of three attacks of paralysis in eight years, in a man of twenty-four.

Deformity.—The most characteristic feature of Pott's disease is the deformity—that is, the projection backward of one or more spinous processes. This is occasioned by the destruction of the vertebral bodies which form the anterior support of the spine. When this is removed, the spinal column above the disease falls forward, throwing the spinous processes out of the vertical line, and causing a projection at the diseased point. The part of the spinal column above the disease, being flexible, can be righted and retain its vertical position, but at the diseased point the adjacent vertebræ lose their mobility, by reason of inflammatory changes, and the projection remains.

The projection is increased, also, as the growth of the spinal segments is affected by the superincumbent weight falling upon the softened vertebræ in an abnormal direction, causing abnormal pressure. Furthermore, the spine is, as has been stated, held in abnormal positions which alter its normal physiological curves and affect its growth.

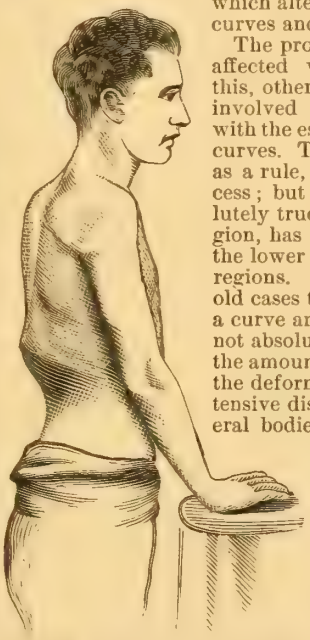

Fig. 3064.—Projection in Lower Dorsal Disease.

The projection is primarily of the affected vertebræ, but, following this, other vertebræ are more or less involved and the curve increases, with the establishment of secondary curves. The sharper the projection, as a rule, the more acute is the process; but this rule, however absolutely true in the upper dorsal region, has occasional exceptions in the lower dorsal and upper lumbar regions. It may be stated that in old cases there is, as a rule, more of a curve and less of an angle. It is not absolutely true that the greater the amount of the disease the greater the deformity, for there may be extensive disease on the front of several bodies though not diminishing the weight-bearing function of all of them; but, generally, the more vertebræ involved the greater is the projection.

Abscess.—In many cases of Pott's disease the whole course is run without any evidence of suppuration, but in others abscesses form a distressing complication. The causes of the development of an abscess are the same in Pott's disease as in caries elsewhere. What are the abscess-determining influences which, in some instances, give rise to profuse suppuration, and the absence of which, in other cases, allows an immunity, is at present conjectural. They may be supposed to be dependent on the amount of constitutional or local power of resistance on the part of the patient; the extent of the bacillary invasion and resulting suppuration; the severity of a previous injury; the individual degree of recuperative power, or of reparative tissue-development. If we consider the situation of the vertebral bodies (the point of origin of abscesses)—projecting into the cavities of the thorax and abdomen, surrounded by the lungs and intestines, close to the large vessels and the œsophagus—it will seem extraordinary that the formation of an abscess does not more frequently lead to a fatal termination. In fact, however, the fluid contents of the abscesses follow in the line of least resistance, and the layers of fasciæ, in most cases, protect the larger cavities of the trunk from invasion; the pus generally extends along the sheath of the muscles and comes to the surface at points distant from its origin, appearing in the neck, the back, the axilla, in the lumbar region, in the groin, or in Scarpa's triangle. These purulent collections are classified respectively as lumbar, iliac, and psoas abscesses.

Abscesses frequently point elsewhere, and not infrequently burst in the mouth, trachea, and bronchi[23] (re-

tro-pharyngeal abscesses[1], occasionally in the alimentary canal,[2] and so rarely in the lungs,[3] exceptionally into the peritoneum or larger vessels. Sometimes the sac descends on both sides of the spinal column, developing apparently two abscesses.

The development of an abscess usually does not give rise to noticeable fever.* Exceptionally the patient, without apparent reason, may develop a marked fever, and the appearance of an abscess several months later will support the belief that the abscess was the cause of the pyrexia.

Pallor, impairment of strength, or an increase in the number of the white corpuscles, with a diminution of the number of red, justify, if existing for some time, an opinion of the existence of a collection of pus. Hectic fever and other septicæmic symptoms do not present themselves unless the abscess-cavity is open to septic invasion, but elevation of temperature may exist. The local symptoms presented by abscesses vary with the locality. Retro-pharyngeal abscesses cause dyspnœa, and dysphagia. Abscesses in the lung give rise to less disturbance than would be supposed—in reality presenting the rational and physical signs of a low form of localized pneumonia,

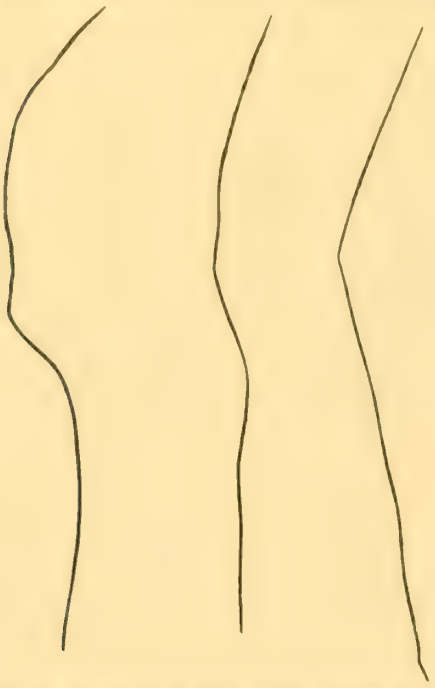

Fig. 3065.—Tracing Outlines of Spinal Curves, showing Change in Progress of Disease. The earliest tracings are on the right.

of chronic or subacute type. The bursting of an abscess into the bronchi is characterized by the discharge of a large quantity of pus, which is coughed up, the amount of dyspnœa, collapse, and danger from suffocation being dependent on the size of the abscess. The sudden discharge of pus is the indication of rupture into the œsophagus,[20] intestines, and bladder; rupture into the peritoneum or communication with large vessels will necessarily be fatal, and there are no symptoms which will give warning of the impending danger.

The course of an abscess is toward absorption or increase. It may remain stationary in size and quiescent for a long time, a condition of things which may be compatible with fair general health. Instances are not uncommon where adults have been able to attend to active work and children to play about, although suffering from a large cold abscess.

When absorption takes place the fluid contents disappear, and the caseous and purulent detritus, if present, in all probability becomes encapsuled. This sometimes happens, even in quite large abscesses.[21]

When the abscess is evacuated, as a rule there is but slight general disturbance, provided it bursts in such a way, and the abscess itself is in such a condition, as to give complete drainage; if it is only evacuated in part, and if the cavity of the abscess is large, extending upward to the spinal column by means of a long circuitous channel which does not admit of complete drainage, fever, with septic changes, usually follows the evacuation of the abscess, varying in different cases in amount and extent.

Fig. 3066.—Complete Bony Anchylosis. (Warren Museum.)

Michel[22] found, in 48 cases of abscess, the localization to be as follows:

In 39 the abscess was about the pelvis; in 6 it was in the neck, and in 3 it was in the dorsal region; of the 39 in the pelvis 13 were about the groin, 14 occupied the iliac fossa, and 2 of these the upper outer part of the thigh in addition, 1 appeared near the anterior superior spine of the ilium; 7 were in the lumbar region; 1 in the perineum; of the 6 in the neck 1 was in the supra-clavicular fossa, 3 at the sides of the neck, and 2 were post-pharyngeal. The 3 abscesses in the dorsal region appeared near the middle line and by the sides of the diseased vertebræ.

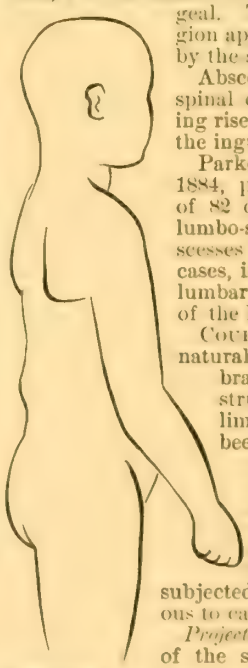

Fig. 3067.—Showing Secondary Curves Above and Below the Projection.

Abscesses may burst directly into the spinal canal, or into the hip-joint, giving rise to hip-disease, or may appear in the inguinal canal, simulating hernia.

Parker (*Brit. Med. Jour.*, January 12, 1884, p. 78) found, in an examination of 82 dorsal, 21 dorso-lumbar, and 37 lumbo-sacral cases of spinal caries, abscesses in eight per cent. of the dorsal cases, in thirty per cent. of the dorso-lumbar cases, and in seventy per cent. of the lumbo-sacral.

Course and Termination.—The natural course of caries of the vertebral bodies is to extend until the destructive process has reached its limit and sound bone-structure has been developed in the granulation tissue caused by the disease. The self-limitation of a carious process always requires time; in vertebral caries it is more than usually delayed from the fact that the vertebræ are constantly subjected to pressure and jar, both injurious to carious bone.

Projection.—The backward projection of the spinal column increases as more vertebræ become involved, and as the adjacent sound vertebræ become altered in shape by altered conditions of pressure. The curve may involve the whole of the dorsal spinal column. This change takes place gradually and does not cause narrowing of the spinal canal; the inter-articular facets become united, and the bodies may be welded together so as to

* Lannelongue found an elevation of surface temperature over these cold abscesses. In the case of a child, seven and one-half years old, with psoas abscess, he found: Surface temperature on normal limb, 98.6° F.; surface temperature over abscess, 99.0° F. On another examination: Surface temperature on normal side, 97.7° F.; over abscess, 98.8° F.[24]

form practically one bone; in cured cases the curvature which has been sharp becomes rounded into a curve with a relatively long radius. In the cervical region, however, this rounding is not as marked as in the other regions. The gibbosity is most marked in caries of the upper dorsal region; the curve in the lumbar region is an arc with a longer radius than is found elsewhere in the spine. The secondary curvatures are, in cervical caries, a dorsal incurvation below the disease, with a slight lumbar excurvation; in dorsal disease an increased hollowing in above and below the gibbosity of the disease; in lumbar caries a long curvature with convexity inward above the disease. The neck becomes shortened and thickened in cervical caries; the trunk is shortened in disease of other parts of the spine; there may be also a diminution in growth of the whole body of an uncertain origin—a complication which fortunately is not common. More usually, in severe cases the limbs grow to the normal amount and necessarily are out of proportion to the length of the trunk. An alteration in the shape of the lower part of the face takes place in marked dorsal disease, with a facial expression which is characteristic; a slight lateral deviation with some rotation sometimes takes place.

A spontaneous arrest of the disease without much deformity may take place in cervical caries, although instances must be uncommon; the same is true of lower dorsal and lumbar disease; the curvature, however, is necessarily larger and the cases less common than in cervical caries.

A spontaneous arrest of upper dorsal and lower cervical disease without the development of noticeable curve, must, if it has ever occurred, be extremely rare.

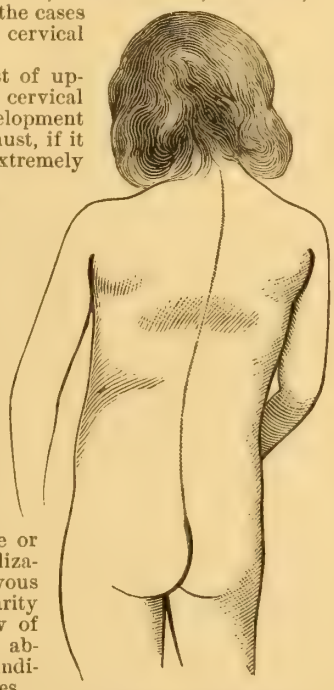

Fig. 3068.—Lateral Deviation in Early Caries of Spine, Upper Dorsal Region.

Diagnosis.—The recognition of Pott's disease in the later stages is easy, but before the presence of the sharp projection, or while that is still small, the affection is often overlooked. In examining a suspected case in the early stage a diagnosis is to be based on the presence of the following symptoms: 1, stiffness in the back; 2, peculiarity of attitude or gait; 3, seat and localization of pain and nervous symptoms; 4, irregularity of outline of the row of spinous processes, or abnormal projection of individual spinous processes.

Normal Flexibility of Spine.—Stiffness of the back due to muscular spasm is very characteristic of caries of the spine. To recognize this it is important to know the amount of normal flexibility of the spinal column. This varies to a degree in individuals, and in children is much greater than in adults. Little difficulty is met in recognizing muscular stiffness in the cervical region. The normal flexibility of the spinal column can be tested as follows: The child is to sit upon a lounge with legs bent slightly at the knee, and should touch the toes with both hands, at the same time placing the chin upon the sternum; or, standing with straight legs and arms stretched out above the head, the child should endeavor to touch the floor with the hands, curving the head upon the chest as far as is possible.[29]

To determine stiffness of the quadratus lumborum and psoas and iliacus muscles, the child should be placed upon the face and an attempt be made to raise the thighs. Normally the spine can be bent to a marked degree, the back sagging as the thighs are raised in this way; in diseases of the lower dorsal or lumbar region the whole trunk will be lifted as if made in one piece, on lifting the thighs.

Stiffness.—Stiffness of the back is an early and a well-marked symptom; it may be absent in the earliest stages of lumbar caries, if the disease is localized in a small focus, not yet involving the cartilage or whole of the vertebral body. Stiffness may be confined to a few of the adjacent vertebræ and not involve the whole back, *i.e.*, patients with cervical or upper dorsal caries in a subacute stage may be able to stoop to the floor quite freely, without indicating any lack of mobility in the lumbar or lower dorsal region. Stiffness of the upper dorsal vertebræ, if limited to a small region and slight in amount, is with difficulty noticed, as normally there is not much flexibility in the upper thoracic region; but for practical purposes, in the usual cases which present themselves for examination, the amount of stiffness is such that it admits of no mistake.

In cervical, and occasionally in upper dorsal, disease the spasm of the muscle produces a torticollis which is sometimes with difficulty distinguished from pure torticollis (independent of any disease of bone).

In torticollis from caries the posterior muscles rather than the sterno-mastoid are usually involved, and there is more spasm than is usual in simple torticollis. The patient, in lying down or in sitting up suddenly, usually

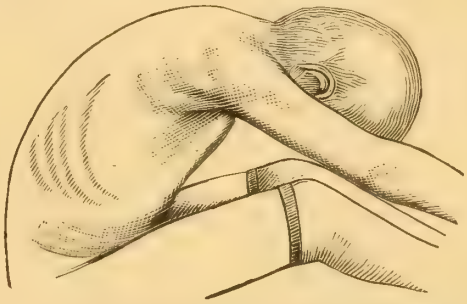

Fig. 3069.—Normal Flexion of Spinal Column.

steadies or supports the head with the hands as a protection against jar or violence. If there is pain it is in the back of the head or shoulders. In pronounced cases there is little difficulty in recognizing cervical caries—there is thickening and a projection in the outline of the neck, the back is flattened between the shoulders, or even hollowed in, with a compensatory projection in the spine in the lumbar region; sometimes in upper cervical disease a projection of the pharynx is to be felt in the mouth.

In examining for peculiarity of gait, attitude, and movement, as mentioned above, the child should be watched narrowly as it runs about, rises from a recumbent position, stoops, etc. In the earliest stages the variation from normal movement may be slight at times.

The nervous disturbances are, as has been mentioned, those dependent on irritation of the nerves issuing from the column at the affected point, and on a transverse meningitis or meningo-myelitis, and consist of pseudo-neuralgias, cough, grunting respiration, or dyspeptic attacks.

Tenderness.—Tenderness on pressure over the spine, although mentioned in many text-books as characteristic of caries of the spine, is rarely present. This is so much the case that tenderness when present is more an evidence of a functional neurosis, hysterical spine, than it is of caries.[30] A tenderness in the spine may occasionally be present in Pott's disease, from a hyperæsthesia of nerves, but even this is rare.

Projection.—The recognition of a projecting knuckle in the earliest stages of caries of the spine is not as easy as might be supposed. In very young children, when fat, the spinous processes are not easily felt, and further-

more, a projection may sometimes be seen normally, in thin subjects, of the spines of the sixth and seventh cervical, occasionally of the first dorsal, and also of the last dorsal and the first and second lumbar vertebræ.

These normal projections differ from the sharp projection seen in caries, in that they are more uniform and more like a longer spinous process, and less like a spine projecting at a wrong angle. A projection of a spine in the middle dorsal, however, must be regarded as presumptive evidence of caries to be confirmed by other symptoms, as a physiological projection in the upper and middle dorsal region (below the first two dorsal) has not been observed in children.[31]

Irregular and pathological projections in the upper cervical region are in the early stages difficult to recognize, owing to the thickness of the overlying muscles; a diagnosis is here rather to be based on the position of the head and the muscular spasm. The shape of the back varies in adults physiologically—the back of a cobbler is different in curve from that of a soldier, and projections in the lower dorsal and upper lumbar regions may be seen in healthy backs.

Abscess.—Abscesses may remain some time without being recognized, when in the thorax or abdomen. Ordinarily, however, they pass down the sheath of the psoas muscle, and the irritation excited by the presence of inflammatory invasion causes muscular spasm and a contraction, more or less marked, of the psoas muscle; this is shown by a peculiarity in gait and by limitation in extension of the thigh. Induration and fluctuation can be felt in the lower abdomen above Poupart's ligament, on deep pressure, often before a swelling is noticeable to the eye.

Retro-pharyngeal abscesses are recognized by the symptoms of dyspnœa, and on palpation a fluctuating projection will be felt in the pharynx.

Paralysis.—A recognition of commencing paralysis is usually possible, from the fact that it is generally preceded by an increase of pain in the abdomen, and an increase of the deep reflexes, knee and ankle, and muscular cramps. The paralysis usually begins gradually, and is first indicated by dragging of one of the legs.

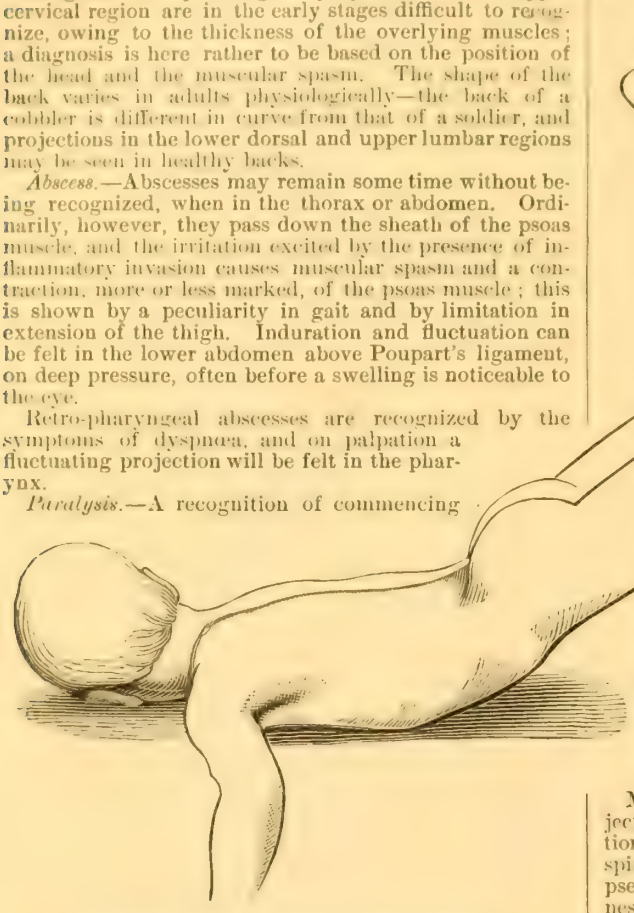

Fig. 3070.—Normal Flexibility of Spinal Column.

Diseases Sometimes Confounded with Caries of the Spine.—The diseases which may be confounded with caries of the spine are the hyperæsthetic spine, lateral curvature, chronic rheumatoid arthritis, chronic articular rheumatism, rachitic spine, malignant disease of the spine, projection of the spine from aneurism, gummata of the spinal cord, meningeal tumors, spondylolisthesis, sacro-iliac disease, caries of the ilium, and hip-disease.

Hyperæsthetic spine, also termed the hysterical spine, the neuromimetic spine, is characterized by tenderness in certain portions of the back, sometimes accompanied by pain or ache. This condition is more common in neurotic persons, but may be seen in others who have been suffering from nervous exhaustion from any cause. The tenderness may be intense and manifestly exaggerated, or it may be only slight and confined to small spots in the lower cervical and upper dorsal or in the upper lumbar region. As a rule, no real stiffness in the back is present, but in severe cases, or in cases which have remained in bed for some time, muscular stiffness may be present. This condition is sometimes seen after railway accidents. In cases that are termed railway spine, abnormal projection or deformity in the spine does not exist. Referred pains, or the attitude and gait characteristic of Pott's disease, are absent. A hyperæsthetic spine occurs in adults, and especially in young, growing girls it may exceptionally be seen in children.[32]

Lateral curvature is occasionally confounded with caries of the spine on a superficial examination. In lateral curvature there is no projecting knuckle of diseased vertebræ, and an error in diagnosis should not be made. In the lateral deviation sometimes observed in caries of the spine there is no marked rotation as seen in lateral curvature.

Rheumatoid arthritis, chronic articular rheumatism, spondylitis deformans of the spine, is an affection of adult life characterized by stiffness and some arching of the spine; there is usually little muscular spasm, and no unusual projection of the spinous processes; in some instances the ribs are anchylosed to the spine, so that no expansion of the chest is possible. Patients suffering from this affection may have neuralgic or pseudo-neuralgic pains of the nerves issuing from the spine at the affected part.[33]

In rachitic curves of the spine the antero-posterior projection is almost always in the lower dorsal and upper lumbar region, such as would be likely to occur in children unable to walk from lack of muscular and bony strength. The projection is not a sharp but a gradual one, and in reality a curve, and unless there has been a change in the shape of the bones there is no limitation to motion, and even if stiffness be present it is slight. Rickety curves are usually seen, and are most marked, in infants unable to walk, or able to walk but little. The curves diminish as the child grows older, but a deviation from the normal curves may persist through life.

Malignant disease of the spine presents, when a projection is found, a more rounded and less sharp projection than is seen in beginning caries. Carcinoma of the spine is usually secondary. The symptoms, however—pseudo-neuralgias, paresis and paralysis, muscular stiffness—are the same in both, and sometimes only a conjectural diagnosis can be made. Carcinoma never occurs in childhood, and primary sarcoma of the spine in childhood must be the rarest of disorders.

Much the same may be said of the curvatures of the spine caused by aneurism, except that the diagnosis is usually made by auscultation or by the rational symptoms before the spine is noticeably affected.

A diagnosis of the meningeal tumors within the spinal canal would necessarily be difficult; the symptoms would, however, be nervous symptoms without affecting the gait or attitude, except through paralysis, unless the pressure of the tumor cause absorption of the vertebræ. This would not happen until a late stage of the affection, and a recognition of the affection would be made easier by the clinical history.

Besides gummata of the spinal cord, a syphilitic destruction of the spinal vertebræ is among the medical possibilities, though it has hitherto escaped record. If it were limited to the bodies of the vertebræ, the symptoms would in every way resemble those of caries of the spine; the clinical history, however, and the age of the patient might serve as guides to an idea of the true etiology.

For the symptoms of sacro-iliac disease, perinephritis and perityphlitis, the reader is referred to the articles treating of these subjects.

A mistake in diagnosis can only happen through a lack of acquaintance with the symptoms of these affections. It should, however, be borne in mind that in perityphlitis and in perinephritis, when an abscess is present a contraction of the thigh may occur resembling that seen in psoas abscess. The absence of a projection or irregularity of the back, or muscular stiffness of the back in these cases, will help to establish the fact that they are not due to caries of the spine. The same is true of caries of the sacrum, and of acetabular hip disease.

The finer diagnostic points are sometimes needed in less pronounced cases, but ordinarily the disease presents itself with well-marked characteristics, even in the earlier stages.[34]

The patient, usually a child, is brought for examination with the statement that there are occasionally sharp pains in the belly, colicky pains, or rheumatism in the legs, that this pain is increased by jar, that riding aggravates the symptoms; there is stiffness after getting up out of bed, or after sitting for a while, and it requires some little running about before the stiffness passes away. The child will occasionally stop in its play, and will lie down or complain of pain, which may be only temporary. On examining the child without clothes, it will be found that there is a peculiarity in gait or attitude; the child walks stiffly, with short steps, bent knees, with head erect, chin thrust forward, and shoulders raised; sits rather than stoops in picking anything from the floor. The child leans against a chair as if tired, and supports the head with the hand; if lying down it gets up slowly and carefully; stands with its hands on its thighs. There is often a grunting respiration and monosyllabic speech, as if deep breathing jarred the spine, a symptom almost pathognomonic of the disease. An abnormal projection of one or two of the spines of the vertebræ, with stiffness, completes the diagnosis; and to this is often added spasmodic action of the muscles of the back, which start out on jarring the spine and are quite noticeable on inspection.[35]

Prognosis.—Pott's disease will always be regarded as one of the most formidable of diseases; its long course, the deformity often entailed, the severity of the complications (abscess, paralysis), and of the symptoms at times, and the occasional termination in death, coming only after years of suffering, or often in a crippled state, give both to the surgeon and to the non-professional public a natural dread of the affection. These inferences are, however, drawn from the severer cases, and facts show that the disease has a tendency to spontaneous recovery, that in certain parts of the spine deformity can be prevented, and that in few affections does the work of the surgeon give greater relief than in Pott's disease.

Mortality.—No statistics of value exist as to the percentage of mortality and recovery. Billroth and Menzel report 23 deaths in 61 cases; Jaffé, 22 deaths in 82 cases; and Mohr, 7 deaths in 72 cases. In a disease having so long a course, for statistics of value a number of patients should be watched for a long number of years. The percentage of mortality would be greater in adults than in children. In a certain number of cases spontaneous recovery has taken place in early childhood. Many specimens exist also in museums showing complete bony union, with entire cessation of the carious process.

Billroth and Menzel found, in autopsies of 702 cases, tuberculosis of other parts of the body in more than one-half (fifty-six per cent.). Amyloid degeneration was found in fifteen per cent. of the cases, and fatty degeneration of the kidney in twenty-two per cent. Mohr, however, found the latter in only six per cent. of the cases collected by him. Mohr found tuberculosis of the lungs in only 8 out of 61 autopsies.

Neidert ("Causes of Death in Deformities of Vertebral Column," Inaugural Dissertation, Munich, 1886) found death, in severe deformities,[36] to be frequently due to heart fatigue; in 24 out of 31 autopsies of cases of this sort, hypertrophy, with or without dilatation, of the right heart was found, accompanied by muscular degeneration of the heart. One died of miliary tuberculosis, eight died of phthisis, one of carbuncle.

Cause of Death.—Michel gives as causes of death in 44 cases of spinal abscess: In 14, tuberculosis of lungs; in 16, marasmus; in 5, sloughing of limbs from œdema; in 4, pyæmia; in 2, arachnitis; in 2, pus in the medullary canal; and in 1, pneumonia.

Mohr, in 9 cases of fatal abscess, found perforation into the œsophagus in 2; pleura and lungs in 2; pleura alone in 1; peritoneum in 1; spinal canal in 2.

Perforation into a large artery has been noted.[37]

Death has occurred from the rupture of a spinal abscess discharging into the bronchi.

Abscess.—The frequency of the complication of an abscess varies somewhat according to the locality of the disease; it is most common in the lumbar, and least common in the cervical, region.

Mohr found, in 61 cases at autopsy, thirty abscesses—of these but one was of cervical caries; and the number of lumbar cases with abscess were twice those of dorsal. In life, in 72 cases abscess existed in but 9.

Cases of recovery after rupture or evacuation of abscess are not so rare as to be exceptional, but abscesses in adults must be looked upon as much more unfavorable as to prognosis than in children. The prognosis will depend largely upon the situation of the abscess, the completeness of evacuation, and the amount of drainage possible.

Paralysis.—Recovery from paralysis in Pott's disease is the rule, and the reverse the exception. It has been demonstrated, in autopsies of cases under observation for a long time, where paralysis had existed and was recovered from, that restoration of nerve-power took place even in a cord which had suffered extensive compression.

Recovery is usually slow, and in some cases requires years. In a few cases, however, recovery is rapid—sometimes surprisingly so—suggesting that the paralysis was due to pressure of an abscess upon the cord, and that when this found an outlet in another direction, the cord was relieved of pressure.

In Taylor's 59 cases, 39 recovered wholly; 5 died of intercurrent affections, and the termination in 12 was unknown.

The writer has observed in one case three distinct attacks of complete paraplegia occurring in four years, with complete recovery from each. The patient died two years later of an intercurrent affection.

Deformity.—The tendency of the deformity is to increase, and this is especially marked in the upper dorsal region; instances of arrest without marked deformity are not so very rare in upper cervical disease, and in lower dorsal disease; but in the upper and middle dorsal regions the tendency is for an increase of the deformity proportionate to the extent of the disease.

It has been frequently stated that a recession of the deformity does not take place. Such instances are rare, but have been observed; the lost parts of the vertebral column are not regained, but growth taking place in the normal vertebræ, and being arrested in the anchylosed vertebræ, the projection is proportionately less, and practically less prominent. As a rule, however, the projection increases somewhat during the growing years, and with it necessarily is an increase in the compensatory curves.

In a few rare cases, an arrest of growth of the whole child takes place apart from the loss of vertebral substance. A peculiarity in the shape of the jaw and face is also observed in cervical and upper dorsal caries.

Prognosis as to Time in Recovery.—No reliable statistics exist as to the amount of time necessary to establish a cure in Pott's disease. The disease varies greatly as to its self-limitation in individuals, and according to the situation and extent of the disease. Necessarily there will be a difference in individual cases in the result of treatment.

Relief from symptoms is often easily obtained, but to establish a complete cure, so that there be no latent disease, requires protection and treatment for years.

It may be said that the bodies in the cervical region

being smaller than those in the lumbar, the time required for self limitation here is shorter than in the lumbar region. In the latter region, also, the superincumbent weight is a more important factor than in the upper part of the spine.

TREATMENT. — *Principles of Treatment.* — The principles of treatment of caries of the spine are simple, though their practical application is attended with difficulty.

The diseased vertebral bodies should be protected from jar and pressure until a cure is accomplished. As in osteitis elsewhere, there is always an effort toward repair, and everything should be avoided which would hinder this reparative process. The jars which come upon the spinal column are chiefly in bending the column forward, and pressure upon the vertebral bodies comes from the superincumbent weight of the head and trunk. In treating a diseased vertebra, therefore, the superimposed weight should be removed from the part affected and all bending forward avoided, the spinal column being fixed so as to secure rest for the vertebral bodies.

Furthermore, as the inevitable tendency of the spinal column, weakened in front, would be to fall forward, deformity will take place, and in treatment every effort should be made to limit the increase of that deformity, or if possible to prevent it.

It will be readily understood that thorough treatment of caries of the spine involves much time, partly because the disease is rarely discovered until much progress has been made, and partly also because the reparative process in bones of the size and situation of the vertebral bodies is necessarily slow. A cure cannot be considered as having taken place, in a structure which has to bear so much weight as the spine, until it is able to sustain, without injury or weight, any jar which may come upon it, otherwise a relapse is apt to occur. It is because so much time is required that surgeons are sometimes obliged to be satisfied with what must be considered imperfect results. Given perfect conditions, it is theoretically as possible to bring about a cure without, as it is with, an increase of deformity, provided a cure can be effected at all. Practically, it is difficult to secure the requisite conditions of complete fixation and ideal position, and perfect results are rarely attained; but it has been shown, by reliable clinical evidence, that prevention and recession of the deformity is sometimes won; that prevention of increase of the curve and cure may in many cases be expected to follow thorough treatment; and that relief and benefit is always to be looked forward to as a reward for careful treatment.

Methods of Treatment.—The methods which have been used to remove from the spine the superimposed weight are recumbency, suspensive and fixative appliances, such as braces and corsets. They constitute the methods of treatment, and have respectively certain advantages and disadvantages which should be clearly understood by the surgeon.

Treatment by Recumbency.—If the patient lies upon his back, or upon his face, on a hard surface, there is no superincumbent weight pressing upon any portion of the spine. If the patient lies upon his back upon a spring-bed, and the bed sags, the spine is, of course, bent, and pressure upon the vertebræ proportional in amount to the extent of the curve, results.[38] This can readily be demonstrated by measuring the length of a person lying flat, and comparing it with the height as he stands. It will be found that there is an increase, while the person is recumbent, of from one to one and a half inch, due to the obliteration of the curves of the spine. If a small pillow is placed under the back so that it is curved with the convexity forward, the bodies are separated in proportion to the amount of the curve.

In thorough treatment by recumbency it is not sufficient that the patient be placed in bed, but he should not be permitted to sit up, lie upon one side (twisting the spine), or bend forward while on his side. The patient, however, can lie upon his face.

The patient, if unruly or restless at night, can be easily prevented from sitting up by pinning the shoulders of the night dress to a sheet, which sheet is secured to the sides of the bed; or, better, by straps in the following way: A soft cloth strap is placed across the bed at the height of the patient's shoulders, and secured at the sides; it is also prevented from moving down by a cross-strap secured at the top of the bed; if the patient's shoulders are secured to the straps by loops around the axillæ (these loops being fastened to the straps), the patient can neither sit up nor roll to one or the other side to any extent. A belt about the hips, secured by side straps to the sides of the bed, will prevent the pelvis from moving sideways, and the patient is thus held sufficiently secure. Sand-bags placed at the sides of the patient also aid to prevent side movements.*

The bed should be flat, and the patient should use no pillows.

This way of securing the patient, however, does not enable him to be lifted or moved readily, and is objectionable on that account. In children this can be obviated by arranging a bed-frame in the following way:

If four stout steel bars, one-half inch wide and one-fourth in thickness, be fastened together so as to make an oblong frame of the patient's height and width, and over this stout sheeting be wound and fastened,† the patient can lie on this, if it be placed upon the bed, as comfortably as upon the bed; straps across the shoulders, fastened to buckles secured to the frame, and others about the hips, will secure the patient in a recumbent position, while the frame and child can be lifted and carried about easily. This arrangement is more comfortable and much cheaper than a Bonnet's wire cuirass, and can be made as efficient in fixing the spine. The same can be used in older persons, but it requires a stouter frame, and there is more difficulty in lifting the patient.

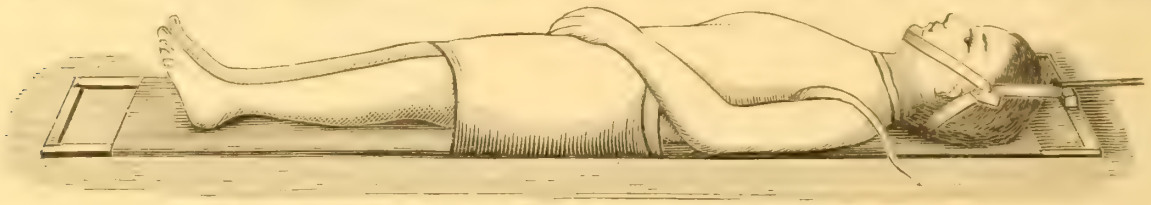

FIG. 3071.—Frame to Secure Recumbency and Fixation, and Allowing Patient to be Moved about.

Distraction, so much used by the earlier French orthopedists, can hardly be thought to directly separate the diseased vertebræ, as was originally supposed, except when applied in the cervical region. Experiment has shown that great force is required to pull the normal vertebræ apart. Distraction, or extending weights applied to the trunk, may, however, diminish the physiological curves, and thus diminish pressure. This extending force is readily applied by means of belts about the pelvis and thorax; these belts being supplied with straps and cords which pass to the foot and head of the bed respectively, and, running over pulleys, exert force by means of attached weights. In some acute cases this affords relief, probably as a correction of muscular spasm, and also as a means of fixing the patient, and possibly, in directly diminishing inter-vertebral pressure.

* An excellent means of retention has been described by Fisher, Lancet, February, 1878.

† The sheeting can be readily changed when soiled; no padding is required. The sheeting should be cut out at the region of the buttock, so that the bed-pan can be used. Distraction of the spine can be employed by attaching an arm at the head of the frame to secure the sling

The pressure of the adjacent vertebræ can be diminished by pads placed under the body, pressing the spine forward. To be efficient they should be thick enough not to flatten to such an extent as to be inefficient, and soft enough to be comfortable. It will be found that curled hair or the best of felt will meet the requirement; they should be so arranged that, as the patient lies on his back, the pressure should come on the sides, and not upon the spines.

In disease of the cervical region distraction will be found of great assistance in acute cases, the relief afforded being often very marked. It is obtained by securing the head in a sling, similar to that used for suspension, which passes under the chin and occiput; to this is attached a cord which runs over a pulley, and is supplied with a light weight (one-half to one pound). Counter-extension is supplied by the weight of the patient's body, if the head of the bed is raised.

Distraction in the lumbar region may also be applied by employing extension by weight and pulley (as in Buck's extension for fractured thigh) to both legs, and raising the foot of the bed.

Treatment by recumbency will be found of service, either alone or in conjunction with other methods, in cases with acute symptoms, in cases of severe cervical caries, and in caries of the lower lumbar region. In children the irksomeness of the confinement passes off readily; but in adults the imprisonment constitutes a serious obstacle to the employment of the method.

Patients who have been suffering will often be found to gain flesh after the relief afforded by recumbency, though the muscles diminish in size in the limbs. Treatment by recumbency, if used, should be thorough. Half measures have the evils of the imprisonment without the benefit of fixation. The limit of its usefulness is usually marked by the restiveness of the patient.

Treatment by Suspension.—The pressure upon the diseased vertebræ by superimposed weight can be removed by suspension.

Suspending a person by the head obliterates the physiological curves (cervical and lumbar lordosis, dorsal kyphosis), and the spine becomes straight as far as its formation will allow. The spine of a new-born child becomes straight by suspension, but in an adult the changes in the shape of the bones and strength of ligaments, and the tension of the muscles, prevent the spinal column from becoming perfectly straight.

In suspension by the axillæ or arms the strain comes upon the latissimus dorsi muscles, and though the superimposed weight which would fall upon the lower part of the spinal column is removed, yet the curvatures in the upper part of the spine are not made straight.

In suspension, in old caries of the spine, it is only the physiological curves which are obliterated; the sharp kyphosis is held too firmly by inflammatory adhesions to permit of correction; in earlier cases with movable vertebræ, the intra-vertebral pressure must be, in a measure, diminished at the point of disease by suspension, but suspension does not cause a disappearance of the sharp angular projections at the point of disease, and in cases that present themselves for treatment the deformity cannot be corrected in that way.

Complete suspension as a remedial agent can necessarily only be used temporarily, in holding the trunk in a better position while corsets and appliances are fixed to the spine. Partial suspension is also used, applied by means of chairs and wheel-carts, or by a sliding pulley attached to a bar in the ceiling, enabling the patient to sit up and walk about without allowing the full superimposed weight to fall on the spine. In patients suffering with the symptoms of Pott's disease, relief will be afforded by suspension without causing much discomfort by the pressure of straps on the head and neck. The amount of time that complete suspension can be used varies with the size and weight of patients.

Suspension will be found to be more efficient in disease of the cervical and upper and middle dorsal regions than in that of the lower part of the spine, as the higher the disease the less the superimposed weight, and the less the difficulty met with in applying to the head an efficient suspending force.

Treatment by Means of Fixative Appliances.—The irksomeness of the method of treatment by recumbency, and the practical impossibility of carrying thorough treatment out in a large number of cases during the whole period of time necessary for complete cure (*i.e.*, until the spine has been restored to its ability to bear weight without likelihood of relapse), has always justified attempts to secure fixation of the spine, permitting locomotion. From the days of Ambroise Paré's hammered brass cuirass to that of the plaster jacket, the corset has been a favorite form; but crutches, springs, and steel supports have been employed in a great variety of ways.

FIG. 3072.—Diagram showing Spinal Column with the Usual Relation of the Bodies in Caries of the Spine.

The tests of an appliance are its efficiency, its convenient use, and the little discomfort felt by the wearer. A large number of appliances used are of no value, simply because they do not meet the conditions indicated by the disease, which, varying in different cases, remain the same in principle, viz., the fixation of the spine in such a position that the jar on the vertebral bodies shall be reduced to a minimum —or entirely removed. This position (aside from recumbency and suspension) would be, if possible, with the spinal column bent backward (concavity backward), so that the point of disease would be in front of the line of superincumbent weight, rather than behind it. This (as the diseased portions are the vertebral bodies in front of the hinge of motion, viz., the articulation) would tend to pry the diseased bodies apart if the spine were flexible, or diminish the superimposed pressure. "To straighten the spinal column in such a manner that the weight of the body is borne on the transverse processes, and not by the bodies of the vertebræ," as has been proposed, is not possible if any disease exists sufficient to cause a projection. This has been proved in experiments on the cadaver, and in suspension of patients the projection at the diseased portion does not disappear. It is possible, however, to diminish, by suspension, recumbency, or certain positions, the amount of inter-vertebral pressure at the point of disease, and to fix or nearly fix the spine in the corrected position.

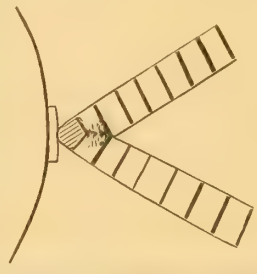

FIG. 3073.—Position of Diseased Bodies made Worse by Flexion of Spinal Column.

FIG. 3074.—Diagram of Carious Spine Straightened by Mechanical Support.

The Treatment by Plaster Jackets.—The most ready method of fixation is by means of Sayre's plaster jacket, which may be applied while the patient is suspended or recumbent.

It was originally supposed that a jacket could be applied so as to serve as a means for holding the diseased vertebræ apart, *i.e.*, of distraction. Suspension having pulled them apart, a jacket taking its base-bearing on the pelvis and a purchase on the thorax, would keep these portions from coming together by an up and down support. These ideas are erroneous. Suspension straightens the spinal column as far as possible, removing antero-posterior curves, and a plaster jacket applied prevents the column from bending forward. Plaster jackets are efficient not as a means of fixation alone, or of distraction, but as a means of securing fixation in an improved position. The treatment by plaster jackets requires care, as a poor

jacket does harm rather than good, deceiving the physician and patient, and for the proper applying of plaster jackets a careful attention to detail is necessary.

Bandages are prepared by rolling loose-meshed cloth in dry plaster-of-Paris. The cloth to be chosen is that capable of carrying the most plaster of Paris, and presenting as little cloth-fibre as possible. Crinoline muslin will be found to answer this purpose. The plaster is to be rubbed in smoothly and to be freed from lumps or unevenness. The patient's clothes are removed and a thin, tightly fitting undershirt applied, made so as to present no wrinkles. The patient is then suspended; the head is secured in a sling which is attached to a strong cord playing in a pulley, or series of pulleys, fastened to a strong point above the patient's head. An assistant pulling on the cord raises the patient so that the heels, and if necessary the toes, are free from the floor. It is desirable to diminish the strain upon the neck, and padded loops connected with the bar raised by the cord and pulley, can be passed under each axilla, or handles may be held* in each hand, connected with cords which play over pulleys. A pull on the cords pulls up the arms, raising the patient. It should, however, be remembered that strain upon the arms or scapulæ, connected as they are to the spinal column by the trapezius and the latissimus dorsi, does not tend to straighten the upper part of the spinal column. Pads are placed over the crests of the ilium, and a large, soft pad over the abdomen. This latter is to be pulled out when the jacket has become hard, and prevents too great pressure on the abdomen.

Fig. 3075.—Appliance for Suspension.

The bandages are placed singly in water and kept immersed until they are thoroughly wet (*i.e.*, until air-bubbles no longer rise in the water from the immersed bandage), and are then wound smoothly around the patient.

If the plaster is fresh and of the best quality, it should harden in from five to ten minutes. The hardening can be hastened by putting salt or alum in the water, but this makes the plaster somewhat more brittle. After the plaster is hard or nearly hard, the patient is to be placed on a soft flat surface, care being taken not to crack the plaster in so doing, the abdominal pad is removed, and the edges of the bandages are smoothed down and cut off if pressing uncomfortably on the thighs or axillæ.

It is important that the jacket should be strong in front as well as behind, and should in front be wound as high as possible, in order to prevent the spinal column from falling forward.

If the jacket become broken it should be removed, and another applied.

Chafing can usually be prevented by careful padding on each side of the prominent vertebral process and over the hips. For the former, the finger of a kid-glove stuffed will often answer, but saddler's felt, cut of the appropriate thickness, will answer better.

It is important that the proper material should be used for the bandages—too close-meshed a cloth cannot retain enough plaster in its fibre, and holds the moisture too long to admit of rapid hardening, which is an essential of a suitable jacket; and a too coarse-meshed tissue, as mosquito-netting, while allowing rapid setting, makes a jacket which is liable to chip and is not sufficiently durable.

Plaster jackets have certain great advantages, when properly applied. In appropriate cases they are efficient, and the surgeon is in no way dependent on the instrument maker; they cannot be loosened at the whim of the patient, and remain as the surgeon leaves them. On the other hand, plaster jackets not being removable, are uncleanly, and to many patients uncomfortable on that account; occasionally an obstinate eczema will develop underneath the jacket.

Plaster jackets can be applied with patients lying in a recumbent position, slung in a thin cloth hammock, the bandage being wound about hammock and patient, and the ends of the hammock cut off (see article Hammock Suspension); or several sheets of crinoline wet in plaster may be wound, layer by layer, about the patient while recumbent, or when suspended.* The usual way, however, will be found to be the readiest.

Plaster jackets may be split, furnished with lacings, and applied and removed at will; they lose thereby a part of their efficiency, as they may be improperly reapplied by the patient.

A plaster jacket which has been split is never quite as firm as before, and though useful in convalescent cases, it will not be found to be as serviceable in acute cases as the uncut corset. As a substitute for plaster jackets, corsets are made of leather, felt, or glue. The plaster jacket applied in the usual way is removed with care, so as to preserve its shape, a plaster mould is taken, and on this as a form a corset is made of sole leather (which when wet can be stretched tightly over the form), of glue, or silicate of potash, by winding bandages or strips of paper soaked in silicate of potash or glue about the mould; felt impregnated with glue has also been used. After this has become hard, it can be split and furnished with eyelets and lacings; it can be applied on the patient who is suspended, as in the application of a plaster jacket. The leather jackets for heavy patients need the reinforcement of strips of steel, which should be accurately fitted to the mould and firmly secured on the jacket.†

These corsets are more neat than plaster jackets, and more durable, but require more time in their manufacture.

A cloth corset reinforced with wire and strips of steel has been used, and it has been found of relief and benefit in certain cases; but when perfect fixation is required, the arrangement is not as reliable as firmer corsets.

In the upper dorsal and cervical region, it is necessary either to add to the plaster jacket an appliance for securing the head (the varieties of which will be mentioned later), or to carry the plaster jacket over the shoulders and neck. The latter is a thoroughly efficient way, but requires care in its application, as it is difficult to apply the bandage so that the head is well supported. The neck should be covered with cotton, the head pulled upward in a sling, and the plaster bandages wound about the neck well up to the occiput and chin, and downward to the trunk and chest. The sling is cut off and pulled out after the plaster has hardened, and the edges of the plaster are trimmed off. If this is well applied, so that the head is well supported, it is not necessary to carry the bandage over the whole head, as has been done.

It need hardly be said that this arrangement is clumsy and not sightly, but it will be found efficient in hospital wards.

A plaster collar applied simply to the neck, and not to the trunk, does not give sufficient support, though it has been occasionally used.

Treatment by Means of Braces.—Besides the objections to fixed plaster corsets mentioned, this criticism may be urged, viz., that the back cannot be readily inspected nor the pressure easily altered from day to day, if the spinal column has become altered in shape or if the appliance has slipped. For proper treatment by fixation of the spinal column, it is important that there should be little

* Most excellent bandages have been applied in this way by Dr. Brown, of Jewett City, Conn. Boston Med. and Surg. Journal, March 20, 1884.

† Felting has been prepared which, when subjected to heat, becomes soft, but stiffens on cooling. This has been used as a substitute for plaster-of-Paris corsets. V. Cocking: Brit. Med. Journal, 1878, p. 283.

or no forward and backward movement near the diseased vertebræ.

To obtain this the spinal column should be made as nearly straight as is possible, and the trunk prevented from bending forward by means of backward pressure on the upper and lower part of the trunk, and forward pressure on the spinal column at the diseased point. It will be seen that if the corset slip, the back changes in shape, so that the pressure will come in such a way that the spinal column is pushed forward above the point of disease, and the appliance will then be an injury. A brace should work on the principle of a lever, the fulcrum being the diseased point of the spinal column, and the power should be applied so that the part above the diseased vertebræ is held back as far as possible, thus diminishing the inter-vertebral pressure at the diseased point. This is true, whether the appliance is a steel brace or a plastic corset, but the regulation and inspection of the fulcrum is more readily attained in a brace, if properly constructed and allowing adjustment, than in a corset, the manufacture of which involves much labor.

The construction and application of a brace should be superintended directly by the surgeon, the details relative to the future result being fully as important as the application of a splint in any fracture, as the result will, in a great measure, depend on the accuracy of adjustment. For the construction of a splint a tracing of the back should be made, which is done as follows: The patient lies upon a hard surface, and a strip of flexible metal (lead or a mixture of lead and zinc) strong enough to retain its position, and pliable enough to be readily bent, is laid upon the back, from the neck to the sacrum, so as to accurately fit the lines of curve presented by the spinal column. The lead is removed, laid on its side upon a piece of stiff cardboard and the inner outline traced. This not only serves as a record, but can be used for a guide in the construction of the brace.

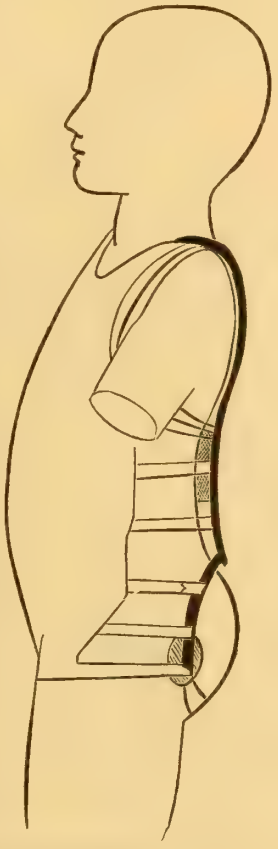

Fig. 3076.—Diagram of Antero-posterior Support, Side View.

Two steel strips, strong enough not to give with the weight of the trunk, are bent according to the pattern, and are connected together at the top by a short strip of steel, and at the bottom by a band half encircling the body; buckles for straps are placed in appropriate places. The two uprights should be separated enough from each other, so that, when applied, the pressure should fall on the transverse processes well padded with overlying tissue, and not on the sharp spines incapable of standing pressure; at the point designed to serve as the fulcrum of the brace pad-plates are placed on each of the steel uprights, at a point which will correspond to the point of disease, and reaching slightly above and somewhat below this. These pad-plates are pieces of steel slightly wider than the uprights and protected from cutting the skin by pads of ground cork, saddlers' felt, smooth leather, or hard rubber. Padding will be needed at the top and bottom of the splint. The appliance should reach as high and extend as low as is possible, in order to increase the power of the leverage. If properly designed it will press firmly at the fulcrum, *i.e.*, the pad-plates and pressure should be uniform at this point and closely fitted to the contour of the curve. The appliance will also touch necessarily at the top and bottom, but the chief pressure should be at the points designed as fulcrum. Variants from this type of construction will naturally be of use, the simplest being that here given: Instead of an upright of a single piece to which a pad-plate is attached, it may be of three pieces, the pad-plate being separate, and fastened to two steel strips extending above and below. This allows the sections to be taken apart and carefully adjusted, but is somewhat more complicated. Instead of the band at the bottom, a curved piece of steel is sometimes of advantage, thereby avoiding pressure in the middle of the sacrum and allowing for careful adjustment. At the top, short strips of steel can be attached which will extend a short distance on to the shoulders and will steady the brace. The construction of the brace does not necessarily involve expensive workmanship, and need not be anything beyond the skill of a village blacksmith; nicety of work being simply desirable in making the appliance more sightly. It should

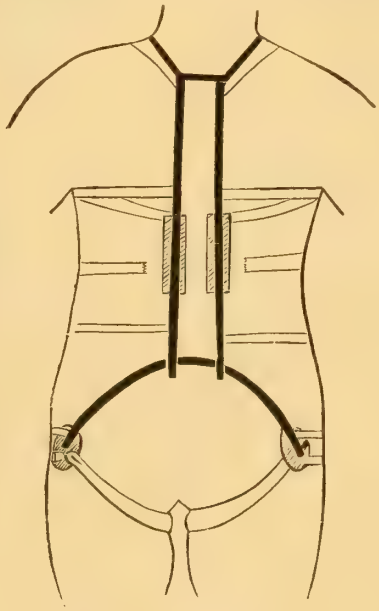

Fig. 3077.—Diagram of Antero-posterior Support, Back View.

be borne in mind that, besides accuracy of fit and proper design, it is of importance that the apparatus be stiff enough so as not to yield as the weight of the trunk falls upon it, inasmuch as yielding involves inter-vertebral pressure. This is true not only of the uprights, but also of the band. A stiff appliance, if properly fitted, can be made as comfortable as a yielding one, and is much more efficient.

It is, of course, essential that the trunk be properly secured to the brace. This can be done by means of an apron, which covers the front of the trunk, the abdomen, and the chest, reaching from the clavicles nearly to the symphysis pubis. The apron is provided with webbing (non-elastic) straps, which are fastened into buckles attached to the brace. Padded straps, passing from the top of the brace around the arms, under the axillæ, and attached to buckles in the middle of the brace, help to secure it; but the scapulæ being movable, cannot be relied upon alone to fix the trunk, and the apron must be furnished with straps at the top which pass over the shoulders to buckles in the top of the brace. The brace can be prevented from being pushed up, and its efficiency in the lower part of the spine may be increased, by padded perineal straps, which pass from the lower part of the

apron under the perineum to the lower part of the brace. The apron will sometimes be found to cut over the anterior superior spines of the ilium and also under the arms, and must be properly padded.

In applying the brace the patient should lie upon his face, and the apron be spread under him. The brace should then be placed in position upon the bare back, or upon a thin, smooth cloth permitting no wrinkles, and the apron strapped to it as tightly as is possible. The more tightly the two are strapped together, the more thorough is the fixation.

The position of the straps and their number will vary in cases according to the situation of the disease, etc. By means of wrenches and a vice the uprights can be bent so as to secure pressure in the proper place, and proper adjustment is not difficult.

The application of the therapeutic principle of fixation in the best possible position varies according as the disease involves the upper, middle, or lower parts of the spinal column.

In the upper region, as elsewhere, it is desirable to prevent the weight of the head from falling upon the diseased bodies of the vertebræ. This can be done in the cervical region by suspension in a sling, similar to that used in ordinary suspension for the application of plaster jackets, which passes under the chin and occiput, and is connected by means of straps to a bent rod, which arches above the head and is bent around the head and neck, being attached below to a plaster, felt, leather, or wire corset.[40] The jacket is kept from slipping down by means of pressure on the hips, if the hips are large enough (which is rarely the case in children), or by means of straps passing over the shoulders; the weight of the head is thus transferred to the shoulders or hips. For a complete transference the amount of pressure under the chin and occiput would in some instances be such that it would be impossible for the patient to open the mouth; but a reduction of the weight of the head on the cervical vertebræ is easily effected in this way, which also prevents the head from bending forward.

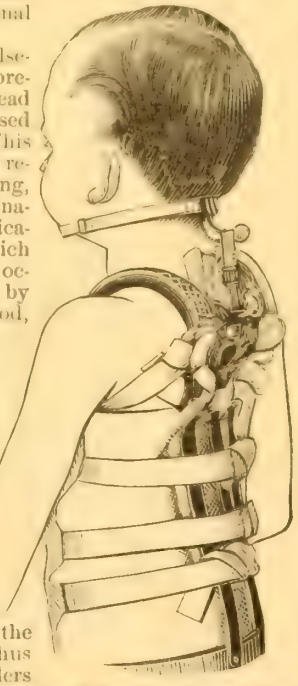

Fig. 3078.—Antero-posterior Support, with Taylor's Chin-piece.*

Instead of a sling, collars of various sorts have been used, which, pressing on the chin and occiput above, and on the sternum and shoulders below, transfer the weight in part from the intermediate cervical vertebræ and check the forward bowing of the cervical region. These collars can be made of plaster of Paris, but are cumbersome and unsightly; more convenient will be found leather collars stuffed with saw-dust, as used by Mr. Thomas, of Liverpool. A collar made of wire-netting, moulded to the shape, and re-enforced by strips of steel, devised by Dr. H. L. Burrell, of Boston, is much more sightly. Collars, however, lack in steadiness, and, in order to secure accurate fixation of the head, they should be connected with uprights which extend below and are attached to the trunk.

A thoroughly efficient arrangement is one used by Dr. C. F. Taylor, of New York—an ovoid steel ring passes around the neck, made so that it can open, and be secured when closed, and arranged so that it can serve as a rest for the chin, and so that pressure can also be exerted on the occiput. This collar at the back plays on a pivot, allowing lateral motion of the head, which pivot is attached to the usual back brace, and can be raised or lowered, as it is desired, to increase or diminish the upward pressure on the head. The back brace should be supplied with padded cross-pieces, which will effect counter-pressure on the shoulders.

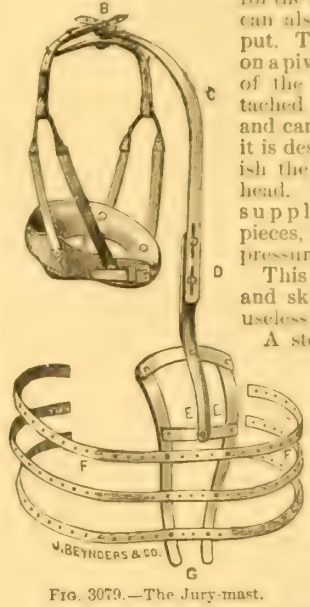

Fig. 3079.—The Jury-mast.

This appliance requires care and skill in application, and is useless unless properly fitted.

A steel-wire support has been devised by Dr. Spring, of Fitchburg, Mass., which is readily made, stout steel wire is bent so as to pass under the chin and lower jaw onto the shoulders and down upon the front of the chest: it is pulled back and up by straps, which buckle onto a back-brace attached to the back and trunk.*

In the lower cervical and upper dorsal region it is difficult to apply suspension efficiently or to completely fix the spine, and the treatment of caries of the spine in this region requires particular care for the arrest or prevention of deformity. The means to be used are the same as those employed in cervical caries.

The mechanical treatment of disease in the middle region is quite satisfactory; the principle of leverage can be applied with thoroughness, and excellent results obtained.

In the lowest region—*i.e.*, in the lumbar region—it is difficult to prevent entirely the forward bending of the spinal column, and in severe cases absolute recumbency is the best treatment; but excellent results are often obtained by the mechanical treatment alone of these cases, for the reason, probably, that the bodies in the lumbar regions are large, and in some cases but a relatively small portion may be affected. The reconstruction of bone is more readily established, and all that is needed is a certain amount of mechanical support; the appliance should reach as low as is possible.

Fig. 3080.—The Jury-mast Applied.

It will be found that the lateral deviation observed in caries of the spine, unless well pronounced change in the shape of the vertebræ has taken

* The principle of antero-posterior support is probably an old one, and its application is wide, its importance was, however, made prominent by Dr. Henry G. Davis, and first brought into a state of practical useful development through the efforts by Dr. C. F. Taylor, of New York, in whose hands most excellent results have been obtained.

For cervical spinal disease allowing a backward lateral movement to the brace, combined with the intention of allowing the spine to straighten and curve backward, but not to bend forward, has been found to be of no practical advantage, and its use has been abandoned, although it is still employed in many of the appliances furnished under the name of Taylor's supports.

* A sight'y and efficient head-support, devised by Webster, will be found fully described in the Boston Med and Surg. Journal, May 18, 1882 p. 409., and a ready method of obtaining support is also described in the Chicago Med. and Surg. Journal, April, 1876.

place, will disappear without difficulty under an efficient antero-posterior support.

The chief objection to the use of mechanical appliances as a method of treatment is, that care and special skill are required not only in the application of braces, but in the inspection and management of the case.

Faulty Appliances.—Unless an appliance works in the way the indications of the disease demand, it is inefficient, and it is on account of faulty construction that appliances have often been found of so little use. A most common fault is that, in order that the appliance may be light, the steel uprights are flexible and give under pressure. It is evident that any appliance which allows bending forward of the spine at the point of disease does not relieve the pressure when relief is most needed; a second fault is that the trunk is often not thoroughly fixed by the straps, etc., of the appliance. If this is the case, the brace becomes simply a frame of steel laid upon the back, and not a therapeutic agent. The exact situation of straps must vary; they should, however, make pressure as high up and as low down on the trunk as possible. If elastic straps are used the value of the appliance is impaired in proportion to the elasticity.

It is of the greatest importance that the fulcrum of the brace should be applied to the right portion of the spine. It is not necessary that the uprights should be applied closely to the whole back, but it is important that at the point of the disease, and for some distance below, the pressure should be thorough, indicating that as the appliance is worn but little motion of the spine at that point is possible. The pad-plates should be arranged so that they may make pressure on each side of the spines, as near as is feasible to each other; pressure directly on the spines cannot be borne.

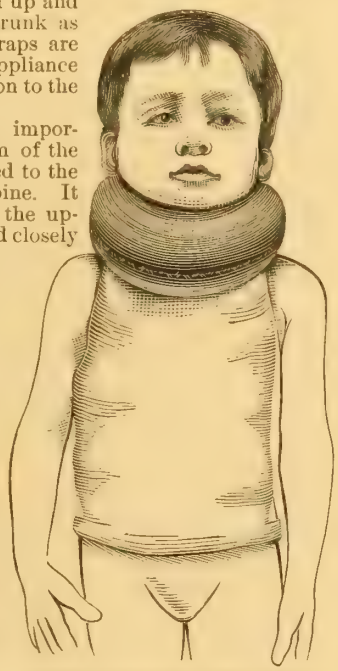

Fig. 3081.—Thomas's Leather Collar.

The use of a crutch-attachment to a brace is very common, and originated from the fact that patients often lean upon tables, or support themselves on their arms. To be efficient, a crutch should have a firm base, but, attached as they are to a steel waist-band, they afford no certain support, and are therefore of doubtful advantage. If a crutch is to be used it can be used reaching to a firm base, as the floor—ordinary crutches (a wheel-crutch) act in this way; but the pelvis of a child is too small to furnish a steady base.

The brace should reach as high and as low on the trunk as is possible.

Treatment of Abscesses.—Treatment of abscesses in connection with caries of the spine does not differ from that elsewhere (v. Abscess), except that, owing to the depth and size of the abscess, it is with difficulty drained. An abscess can be treated by expectancy, by aspiration, by injection of fluids—iodoform and glycerine—to promote absorption, and by incision.[61] When expectancy fails, aspiration is usually resorted to; this, however, is often of little assistance, as the contents of the abscess are usually mixed with caseous masses which block the needle. A large, free surgical incision gives better drainage than a natural fistulous opening, and saves, if the abscess is situated under tense fasciæ, the patient from many months of discomfort. The essential of successful incision of an abscess is complete drainage; thorough asepsis is of the next importance. Many patients make good recoveries after incision of abscesses, where no antiseptic precautions have been taken; but the course is much less tedious, attended with much less risk, fever, and suppuration under the strictest asepsis than under other circumstances.

Drainage is sometimes difficult to secure. Counter-opening in the back, through the quadratus lumborum—near the spinal column—or, if large abdominal abscesses are present, direct incision in the back, with counter-openings in the groin are indicated.

The incision of lumbar and psoas abscesses used formerly to be regarded with much dread. In cases with large abscesses, especially in adults, where the pus has channelled its way through a long and devious course before coming to the surface, and where asepsis is not thoroughly maintained, the patients are often not benefited by incision, and the death from hectic and exhaustion, inevitable in a natural opening in these cases, is not averted, and the result is merely anticipated by surgical interference. When, however, drainage and asepsis can be carried out, incision is not only free from danger, but is of great benefit to the patient.

Direct Incision and Removal of Carious Bone.—Direct incision down to the spinal column in caries, curetting the carious vertebræ, has been proposed and done; the results so far have not been encouraging.

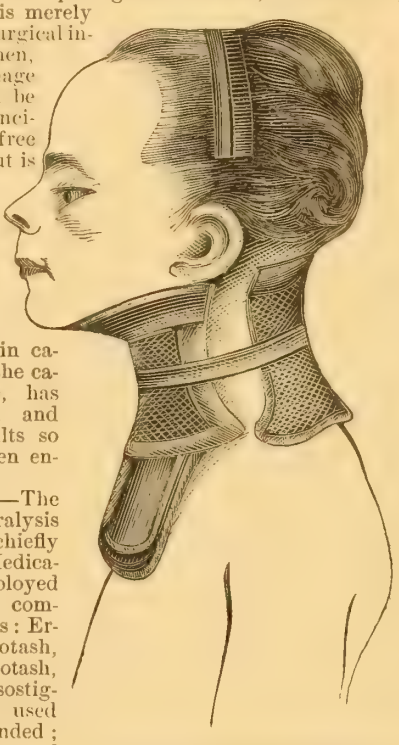

Fig. 3082.—Burrell's Brass Wire Collar.

Paralysis.—The treatment of paralysis is at present chiefly expectant. Medication is that employed in meningitis, compressive myelitis: Ergot, iodide of potash, bromide of potash, strychnia, physostigma, have been used and recommended; local application of blisters, cautery, ice, hot water, have been recommended, and the use of the cautery is especially advised by neurologists.

The natural course of the paralysis is in recovery, and in many cases this comes unexpectedly; so that a careful estimate of the effects of different agents is difficult. Recovery takes place in a large majority of cases under any treatment.

The actual cautery is a tradition of the neurologist, based on theoretical grounds and founded on improvement noticed in a few cases. In view of the very satisfactory results obtained without the use of the cautery, so barbarous a means should not be employed, unless supported by stronger claims than can at present be urged.

Constitutional Treatment.—Means for improving the patient's general condition are important, and are such as are employed in patients with the tuberculous state elsewhere in the body: Care as to diet, proper nutritious food, tonics and digestives, and such medicines as are regarded as reconstructive (cod-liver oil, the hypophosphites of lime, soda, iron, quinine, etc.). As in all chronic diseases, medication should vary with the patient's condition. The

patient should be weighed from time to time and an estimate formed as to whether his condition needs fattening or restricted diet, and whether the amount of exercise allowed should be increased or diminished.

Exercise and fresh air, the best of tonics, are to be directed in such cases, and to such an amount as the acuteness of the symptoms, the danger of access of disease by possible falls and jars permit, it being borne in mind that no appliance can be used which will be so thorough a means of fixation that injury may not follow violent falls, and also that, to favor the reconstructive process essential to the arrest of caries, a certain amount of exercise, sunshine, and freedom from the imprisonment of the sick-room, are of the greatest advantage. Judgment as to the relative importance of these different dangers constitutes the treatment of the disease.

Summary.—The proper treatment of caries of the spine is not the application of any method, the use of any corset or brace, but the employment of such means as are most efficient for carrying out the object aimed at. A brace is useless in the case of persons unable to adjust it, a plaster jacket applied about the trunk is useless and brutal surgery in disease of the cervical or high dorsal region. Recumbency, carried to a point of depressing the patient's mental and physical condition, is as much of a mistake as to drag a patient about who is anxious to lie down.

In the treatment of these cases, the surgeon should be familiar with the advantages to be gained by all methods, and to employ each as the case may demand, and for such a length of time as the circumstances of the case may require, or combine the different methods as may be advisable.

In a general way he may formulate to himself that: In acute, painful cases absolute recumbency with fixation, combined with extension in disease of the upper part of the column, is the best method until the active stage of the disease is passed; in middle and lower dorsal caries, an immovable plaster jacket, without head attachment, will be found of great help for cases in the care of negligent people.

In stages of convalescence, removable stiff corsets, made of leather, glue, plaster-of-Paris, etc., can be used with advantage.

In diseases of the cervical, dorsal, and upper lumbar regions, some mechanical appliances must be used if the patient is not recumbent, and the choice will be directed by the circumstances of the case (amount of care, expense, sensitiveness as to appearance) between a plaster bandage holding neck and trunk, collars, braces, etc.

In the lowest lumbar region recumbency, with or without fixation by extension, constitutes the most thorough method of treatment, braces or corsets being of value as a help for fixation during recumbency or in the stages of convalescence, and where recumbency is unadvisable.

Properly constructed braces, designed so as to apply thorough antero-posterior support, with fixation in an improved position, form a method of treatment most satisfactory to the surgeon capable of controlling and inspecting his patient. For such treatment, however, care on the part of the attendant of the patient, and ready facilities for the adjustment of braces, are necessary.

Whether recumbency for a time is required, or whether ambulatory treatment with fixation appliances is sufficient, are questions of judgment in individual cases.

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